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THE CHANGING GEOGRAPHY OF ARABIA

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A basic concept in modern geography is that *man lives in a changing world*. The patterns of yesterday are modified, in some degree, by today. Resources change, man changes, and man-land relationships change. Naturally, then, those who teach geography often must revise their materials and their emphases. Arabia furnishes a striking example of the need for such revision, although some people might assume that the geography of a desert area would change little.

The geography texts of several generations stressed five standard items in the geography of Arabia—the dry climate, the sandy deserts, the nomadic Bedouin tribes, the isolated oases, and the camel caravans. A rather typical description appears in *The World at Home*, published about 1890 by T. Nelson and Sons, London, Edinburgh, and New York. According to this book—

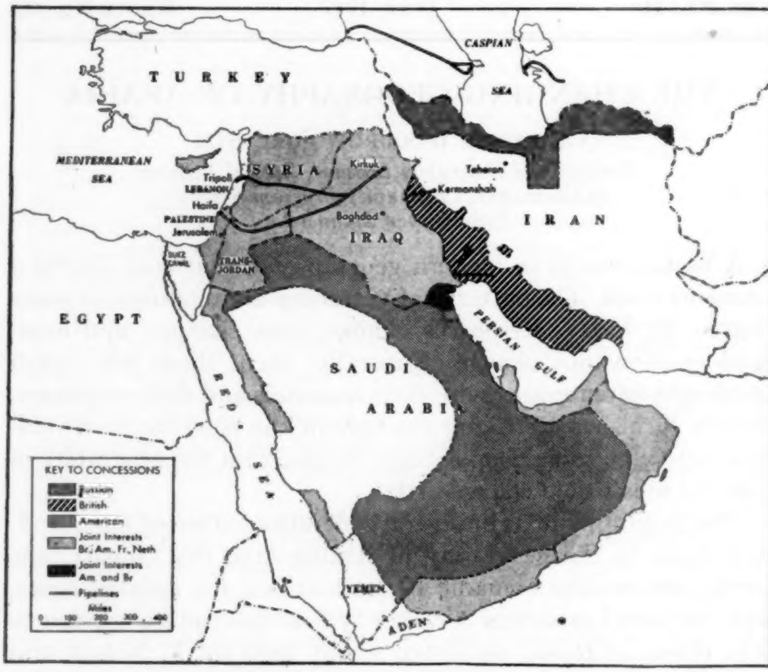
"Arabia is a large peninsula, bounded by the Persian Gulf, the Red Sea, and the Arabian Sea . . . . A large part of Arabia is desert. Wherever . . . wells . . . occur with a sufficient supply of water, towns and villages, with gardens around them, have sprung up. These, however, are widely apart. The desert surrounds them like a sea. Each town is an independent state.

"The desert outside, though untenanted by any settled population, is roamed over by the Bedouin tribes, which form the bulk of the Arab race. . . . The Bedouins use horses in their war expeditions; but in making long journeys . . . the camel chiefly (is) used.

"With a few necessary articles . . . (the Arab) . . . is contented. Mats for his tents; ropes made from the hair of his goats and camels; pots for carrying fat; water-jars; earthenware bowls or gourd shells for holding milk; leathern water-skins for the desert; and sheep-skin bags for his clothes;—these are the requirements of the Arab.

"The desert life of the Arab is to-day the same as it has been for thousands of years."

This description may have been adequate when it was written. But it will not suffice in 1947. True, the larger part of the



From "Old World Lands" by Barrows, Parker and Sorensen Silver Burdett 1947

OIL CONCESSIONS IN THE NEAR EAST

Arabian peninsula remains a desert land. Oasis villages still are found wherever there is a good supply of water. Bedouin nomads roam the desert much as they did long ago. Many Arabs travel by camel. Nevertheless, significant changes have come to Arabia. Some new and important items have been added to the "standard five." The Arabian peninsula has a new geographic personality and a new set of relationships to the world around it.

It no longer is true that each town in Arabia is the equivalent of an independent state. Most of the peninsula is within the boundaries of one country, Saudi Arabia. This country is no loose confederation of Arab tribes, but is a tightly organized kingdom ruled by an absolute monarch, Ibn Saud. The country appropriately carries his name because it was he who welded the people into one nation.

Travel in Arabia at the present time is not limited to journeys by camel. Automobiles and trucks have made their appearance on many caravan trails. In 1943, two correspondents for *Life* visited Riyadh, capital of Saudi Arabia. They traveled all the way across the peninsula by automobile. They were accompanied, part of the way, by a group of soldiers in a Chevrolet truck.

Ibn Saud himself has made much use of automobiles. In the course of one of his wars he transferred some of his cavalrymen from camels to motor-cars, and won handily. Hundreds of trucks are in constant use by the government, for various purposes. When the king makes his annual pilgrimage to Mecca, he goes by automobile. The convoy which carries him and his retainers may number hundreds of vehicles.

The automobile, the airplane, and the radio all have helped to destroy the old isolation of Arabia. Until the turn of the century, the peninsula was one of the least-known areas in the world. Thousands of square miles were entirely blank on the world's best maps. Now there are good maps of the peninsula, based largely on aerial photographs.

Fifty years ago many thousands of Arabs knew of no world but their own. Automobiles helped to make them aware of other lands. The radio also helped. Nearly every village in the country now has at least one receiving set. The listeners have a fairly wide choice of programs, broadcast from cities such as Cairo, Damascus, and Baghdad. In Riyadh, careful attention is paid to news broadcasts from capitals such as London and Moscow.

The world struggle for oil has reached Arabia. The map accompanying this article shows how the Near East has been divided in terms of oil concessions. The Arabian American Oil Company owns the concession for most of Saudi Arabia. This company is owned jointly by Standard Oil of California and The Texas Company. Along the western coast of Saudi Arabia the Americans share their interests with the British, the French, and the Dutch. A similar arrangement is in effect in Palestine,

Trans-Jordan, Syria, and Iraq. Already the production of oil in Saudi Arabia alone is measured in tens of millions of barrels each year.

This development of oil resources has affected the way of life of many people in Arabia. The oil companies have employed some Arabs as guards, or as guides, or as laborers. For many years Ibn Saud dreamed of getting the nomads to settle down to farming. This was difficult to accomplish because there was no extra land where there was water enough so that men could grow crops. Now some of the government income from oil has been spent for dams, wells, and canals. Thousands of acres of land have been brought under irrigation. And thousands of people who once were nomads now are farmers. In 1947, the bulk of the Arabs are farm people, not nomads.

Occasionally the American oil companies have given some direct aid to the irrigation program. They have used their equipment to drill wells of *water* for Ibn Saud. To the oil men, this was child's play. To the ordinary Arab it seemed almost a miracle. In many places, the water level in the ground was far out of reach of anyone who tried to dig by hand.

It is not surprising that the world now pays much attention to Arabia. The area not only has oil, but is strategically located at a great world crossroads. Furthermore, Saudi Arabia is one of the leading powers in the Arab League, a seven country political bloc in the Near East. After the Yalta conference, early in 1945, Franklin D. Roosevelt stopped in Egypt long enough to meet King Farouk of Egypt, Emperor Haile Selassie of Ethiopia, and Ibn Saud of Arabia. Ibn Saud had boarded a U. S. destroyer at Jidda, on the eastern shore of the Red Sea. With him, according to news reports, came the deputy foreign minister, the finance minister, and other Arab officials. They sailed northwest about 800 miles, to Egypt. In a lake along the Suez Canal another U. S. ship was waiting. On board that ship, the President of the United States received the absolute monarch of Saudi Arabia. Arabia's world relationships certainly had changed since the day when it could be written, "each town is an independent state."

The geography of Arabia, then, is not as simple as it once was. Important new factors must be considered when the man-land relationships are described. It is true, of course, that only a very few persons in Arabia have their own radio sets or automobiles. Nevertheless, most of the people have been affected, to some degree, directly or indirectly, by the changing world.

A modern geography of Arabia must weigh the importance of new means of transportation and communication, new political institutions, new tools, and new knowledge. There are new resources in farm land and oil. It is not even accurate to say, any more, that the Arabs are content with "a few necessary articles." World contacts have brought new desires, and oil money has provided some new imports.

The new geographic relationships in Arabia probably are more difficult to teach than the "standard five" items. However, the new patterns must be taught, at appropriate levels, if the child is to know the world in which he lives. To disregard change in Arabia, or in any other part of the world, is to deceive the pupil. The field of geography cannot be static, for the world itself is not static.

AN IMPORTANT ANNOUNCEMENT TO ALL SUBSCRIBERS

THE BOARD OF DIRECTORS OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, MEETING ON MAY 10, 1947, DIRECTED THAT THE SUBSCRIPTION RATE OF THIS JOURNAL BE INCREASED TO $3.50 PER YEAR, EFFECTIVE AT ONCE.

THIS ACTION WAS TAKEN RELUCTANTLY AS ABSOLUTELY ESSENTIAL IN THE FACE OF CONSTANTLY RISING COSTS OF PAPER AND PRINTING.

ADDITIONAL POSTAGE REQUIREMENTS WILL CONTINUE AT 25¢ TO CANADA AND 50¢ TO FOREIGN COUNTRIES.

SCHOOL SCIENCE AND MATHEMATICS WILL MAKE EVERY EFFORT TO CONTINUE TO PROVIDE THE MAXIMUM POSSIBLE VALUES IN EDUCATIONAL MATERIALS AND SERVICE TO ALL READERS.

FM BROADCAST TRANSMITTERS FOR COLLEGES

A plan to provide colleges throughout the country with small low-powered FM broadcast transmitters at less than a quarter the cost of previous equipment, and thus eliminate the cost barrier to non-commercial educational broadcasting, has been proposed to the FCC and the U. S. Office of Education by the General Electric Company's Electronics Department.

The establishment of such stations on a wide scale would encourage adult as well as student educational programs and at the same time help train thousands of students to help meet the demand developing for commercial FM station personnel.

The G-E FM station plan calls for use of a small transmitter with a power output of two and a half watts. This would be the modulator section of a large G-E FM transmitter. It would enable the schools to use available educational FM broadcasting channels.

AN APPLICATION OF DEGENERATE CONICS

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The equation of the tangent line at any given point of a circle can be obtained directly by eliminating the terms in x^2 and y^2 between the equation of the circle and the equation of the point circle at the given point. For example, the equation $x-5y-9=0$ of the tangent line to the circle

$$x^2+y^2-6x-8y-1=0 \quad \text{at} \quad (4, -1)$$

is obtained by eliminating the terms in x^2 and y^2 between the equations $x^2+y^2-6x-8y-1=0$ and $(x-4)^2+(y+1)^2=0$. The purpose of this note is to generalize the above result.

The equation of the tangent line at any point (x_1, y_1) of the conic

$$Ax^2+Bxy+Cy^2+Dx+Ey+F=0 \tag{1}$$

can easily be obtained by eliminating the terms in x^2, xy, and y^2 between equation (1) and the equation

$$A(x-x_1)^2+B(x-x_1)(y-y_1)+C(y-y_1)^2=0$$

of a degenerate conic which is similar to conic (1) and similarly situated. After performing the subtraction and making use of the fact that the point (x_1, y_1) is on conic (1), one may write the desired equation in the form

$$x(2Ax_1+By_1+D)+y(Bx_1+2Cy_1+E)+Dx_1+Ey_1+2F=0. \tag{2}$$

By use of the methods of calculus or of analytic geometry for writing the equation of a tangent line at a given point of a curve one can prove that equation (2) is the equation of the tangent line to conic (1) at the point (x_1, y_1).

To illustrate the process outlined above let us find the equation of the tangent line to the conic

$$x^2-xy+y^2-x-y=0 \quad \text{at} \quad (1, 2).$$

We have merely to eliminate the terms in x^2, xy, and y^2 between the equations $(x-1)^2-(x-1)\ (y-2)+(y-2)^2=0$ and $x^2-xy+y^2-x-y=0$ to obtain the equation $x-2y+3=0$ of the tangent line.

MOSS MATERIALS FOR TEACHING

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Mosses are very easy to preserve and prepare for study in class or laboratory. Let us consider as an example a genus which has a broad range of distribution, *Polytrichum*, commonly known as the Hair-Cap Moss.

The leafy gametophytes are quite conspicuous to a collector walking through the woods or field. Closer observation gives evidence of a slight difference in appearance of the plants growing in proximity. The uppermost "leaves" in some of the plants are spreading and somewhat horizontal in arrangement, producing a saucer-like structure at the upper end of the "stem." These are the male plants and in the central portion of this rosette the antheridia are located. The uppermost "leaves" in other plants are suberect to erect. These are the female plants and at the upper ends of the "stems" the archegonia develop.

For the sake of convenience and saving time the teacher may collect the sexes separately, pulling the plants gently from the ground so as to keep the entire plant intact, and placing a definite number (for example 25) on a sheet of paper slightly larger than the plants. Each group of twenty-five may be rolled and tied with string. Each roll should be marked on the outside as to number and sex of plants inclosed.

It is probable that there are also plants bearing the sporophytes and calyptras in the same habitat. Caution must be used in collecting and packeting each plant so that the calyptra or hairy cap does not drop off. The sheets of paper in which these plants are rolled should be long enough to fold over at both ends of the roll, thus not losing the parts which separate easily from the rest of the plant, such as the calyptra and the operculum.

Upon returning to the laboratory these rolls may be placed in formalin (made according to the ratio of commercial formalin 10 cc. to water 100 cc.) in a container (for example, a quart or two quart fruit can or a large mayonnaise jar) from which the required number of rolls for the classes may be removed conveniently. The name, locality, date, collector, and habitat data may be written or typed on gummed paper or label and placed on the outside of the jar. Since some students may dislike the odor of formalin, a few hours before the beginning of the laboratory

it is advisable to remove from this solution rolls sufficient to meet the class needs and place them in vessels filled with water. The large glass preparation and sorting dishes are very convenient for this purpose. Each kind of plant (male, and female with and without sporophytes) may be placed in a different bowl. The strings may be cut and the papers unrolled and removed from beneath the plants. The complete plants are now ready to be issued to the students as needed in the laboratory exercise. The appearance of the plants will be practically the same as when collected. Materials not dissected may be wrapped and returned to the formalin solution for use in future years.

Another method, more convenient perhaps, consists of placing the plants in commercial envelopes or packets made of newspaper, writing paper, etc. The size of the wrapper should be ample to accommodate the plants without bending or breaking them. The name and the collection data may be written on the envelope or packet or inclosed within on a slip of paper. The plants will dry within a day or so if the packets are allowed to stand in a loose arrangement on the laboratory table. The packets may be stored indefinitely in a box. Caution must be exercised in packing to prevent breaking the plants. A few hours before the class is to study the specimens, they may be removed from the packets and immersed in water in the glass preparation dishes. In a very short time plants will assume their natural appearance. At the close of the laboratory the plant materials which were not dissected may be removed from the water, returned to the packet, dried, and stored again in the box.

If the teacher is fortunate in having mosses grow near the building in which the classes are taught and the plants may be studied when all phases of the life cycle are available, the plants in natural condition are better for study than the preserved or dried specimens.

In a greenhouse, or in a terrarium in the laboratory or the greenhouse, it is possible to keep mosses, transplanted from the woods or field, growing for long periods of time if one attempts to maintain as nearly as possible the environmental factors of the habitat from which they were removed. The project is interesting to the class for observation or (and) experimentation as well as supplying living materials for class study.

Riker Specimen Mounts of common mosses, in "fruit," are very good for display in the laboratory or for student observation during the class discussion.

The protonema stage is not often noted in the field by the collector. If found and brought to the laboratory, the student has difficulty in separating it from the soil in preparing a mount for microscopic study. Upon the basis of experience, the author recommends collecting, whenever discovered, a thin layer of soil covered with the green felt-like protonema of *Pogonatum*. The dried material may be kept indefinitely in envelopes or paper packets for class observation or laboratory study. Since the filaments occur in mass, it is convenient to prepare mounts free from soil particles for study through the microscope. A few minutes before needed, the pieces of dirt, bearing upon their surfaces the mat of green protonema, may be placed in a watch glass containing enough water to moisten the soil. Soon, the protonema is moist and appears as though it had just been collected. With a pair of tweezers filaments of the protonema may be removed, free of soil particles, and used in preparation of a mount for study through a microscope. When the exercise is completed, the pieces of soil should be allowed to dry and returned to the packet for use at another time.

The author uses *Polytrichum* in classes because the plants are sufficiently large for students to dissect conveniently and successfully, the gametophyte and sporophyte parts may be seen with the unaided eye, and the urn may be quickly sectioned by the student, with a scalpel or safety razor blade, just beneath the mouth. The peristome, then, may be mounted for study through the microscope.

Although the writer has cited only two genera for the sake of explaining the methods of securing mosses for classes, other mosses are very satisfactory. The species available in the community in which one teaches and at the time needed will prove to be just as useful. *Mnium* and *Atrichum* (*Catharinea*) are recommended, also, using plants sufficiently large for convenience in study of all parts.*

There are several keys and manuals to the mosses of various states or sections of the United States. Two recent publications contain keys, descriptions, and illustrations for mosses of North America.

Manuals of the Mosses

A. J. Grout, *Moss Flora of North America north of Mexico*, vol. 1, 1936-

* The time of maturity of antheridia, archegonia, and capsules varies with different species. With regard to several of the common mosses, April, May, and June are profitable months for collecting functioning antheridia and archegonia, and May, June, and July, the mature capsules.

1939; vol. 2, 1940; vol. 3, 1928. Published by A. J. Grout, Newfane, Vermont.

H. S. Conard, *How to know the Mosses*. 1944. Published by H. E. Jaques, Mt. Pleasant, Iowa.

SALARY SCHEDULE FOR TEACHERS

Whitefish Bay Public Schools

Revised: 1929, 1936, 1945 and March 1947
(Effective Sept. 1, 1947)

Classification	*Minimum*	*Maximum*	*Increment*
Bachelor's Degree	$1,800.00	$3,600.00	$100.00
Bachelors plus 15 credits	1,900.00	3,700.00	100.00
Bachelors plus 30 credits	2,000.00	3,800.00	100.00
Master's Degree	2,100.00	4,000.00	100.00
Masters plus 15 credits	2,200.00	4,100.00	100.00
Masters plus 30 credits	2,300.00	4,200.00	100.00
Doctor's Degree	2,400.00	4,400.00	100.00

Provisions:

1. This schedule applies to contract teachers including married women formerly on contract.
2. Some experience may be required for the minimum salary at the discretion of the board.
3. Department Heads and Deans are to receive 2.25 years' credit on the salary schedule, if such adjustment has not been made, and to advance $225.00 above the maximum.
4. The board reserves the right where a teacher's work has not been entirely satisfactory to withhold the increment.
5. The initial salary of a teacher entering the service shall be a matter of adjustment between the school board and the teacher.

Provisions for Advanced Study:

1. A credit means a semester hour credit which is earned by one hour of study per week for 18 weeks or its equivalent.
2. Credits will be accepted only from approved institutions of higher learning.
3. Credits may be graduate or undergraduate.
4. Where a teacher has credits above a bachelor's or master's, his college must indicate that the credits were not used to gain a degree.
5. A copy of the credits must be filed in the central office as a permanent record.
6. Contracts will be adjusted in September and February of each year to give credit for advanced study.
7. The permission of both the principal and the superintendent must be gained for a teacher to take classes during the school year.

Plastic tableware, complete with plates, cups, saucers, bowls and platters, is designed for heavy duty because the dishes are practically unbreakable under ordinary use. Made in various colors, the plastic articles resemble usual tableware, are tasteless, resistant to fruit juices, and not injured by boiling water.

TIME CURVES

WALTER H. CARNAHAN
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The calculus was invented by Newton about 1665. Leibnitz independently invented the method and perfected its symbolism between 1673 and 1684. To provide exercises in the application of the powerful new method the old practice of issuing challenge problems was revived by mathematicians. There were many able mathematicians living at that time to give and accept these challenges. Besides Newton and Leibnitz, there were James and John Bernoulli, Christian Huygens and others. Each had his own characteristic part in issuing and accepting these challenges. The brothers Bernoulli were frankly enemies and liked to get the best of each other; Leibnitz liked to show off the power of the science he had helped to perfect; Newton liked to solve the challenge problems but did not like publicity, and so he characteristically worked anonymously. Huygens was interested in the problems only to the extent of their application to physical situations which he was investigating. Two of the time curves discussed below were discovered during this period of mathematical challenges.

The Isochrone. In 1687 Leibnitz challenged the other mathematicians of Europe to find the equation of the isochronous curve, the plane curve along which a ball rolls under the force of gravity so that it falls equal vertical distances in equal time intervals. James Bernoulli was the first to publish a solution in 1690. Probably Leibnitz had solved the problem before he issued the challenge. Later John Bernoulli and Huygens published solutions.

The isochrone is the semicubical parabola $x^2+y^3=0$. (One equation). It is the evolute (locus of centers of curvature, or envelope of normals) of the parabola $x^2+4y-8=0$.

The Brachistochrone. In 1696 John Bernoulli challenged mathematicians to find the equation of the brachistochrone, the curve along which a ball would fall from one point to another in the shortest possible time under the impulse of gravity. Probably John had solved the problem before proposing it for others to solve. Leibnitz solved it the day he received it. James Bernoulli published a solution. A solution appeared in the publication *Philosophical Transactions* in London but the name of the mathematician was not given. John Bernoulli knew that New-

ton was the only British mathematician capable of solving the problem and said, "*Tanquam ex ungue leonem*," which can be translated very freely as "One can identify the lion by his tracks." Guillaume l'Hospital, a student of John Bernoulli, also found a solution.

The brachistochrone is the cycloid, the curve traced out by a point on the circumference of a wheel rolling along a straight line. Its equations are

$$x=a(\theta-\sin\theta)$$
$$y=a(1-\cos\theta).$$

a is the radius of the wheel. Even though the point to be reached by the falling ball must be reached by rolling to the bottom of the curve and then climbing up a considerable distance, the cycloid is still the curve of quickest passage from point to point.

FIG. 1

The Pendulum. The pendulum does not belong among the challenge problems which we are presenting but makes use of a time curve, in the usual case, a circle. Everyone is familiar with the story of Galileo and the swinging lamp in the church that suggested to him the possibility of using a pendulum for measuring time. He lived sixty-five years before Huygens who made the first pendulum clock by applying Galileo's idea. However, Huygens knew that a pendulum moving on an arc of a circle does not always vibrate in the same time, that the amplitude, or length of the swing, as well as the length of the radius of the arc has some effect on the time of a beat. The time T of a full swing of a pendulum of length l is precisely given by the formula

$$T=4\sqrt{\frac{l}{g}}\int_0^{\pi/2}\frac{d\theta}{\sqrt{1-\sin^2\frac{\alpha}{2}\sin^2\theta}}$$

$$=2\pi\sqrt{\frac{l}{g}}\left(1+\frac{1}{4}\sin^2\frac{\alpha}{2}+\frac{9}{64}\sin^4\frac{\alpha}{2}+\cdots\right).$$

In this formula, $g=32.2$, 2α is the arc through which the pendulum swings, and θ is the arc between the pendulum at any time of its swing and the lowest point of its swing. Hence $\alpha/2$ is constant for a good pendulum and $\sin\theta$ is a variable.

The ordinary clock pendulum moves on the arc of a circle under the impulse of gravity, and the above formula states the time law of its fall. If α is small, $\sin\alpha/2$ is so nearly zero that the terms of the non-terminating series after the first (which is 1) can be neglected, and the formula then reduces to $T=2\pi\sqrt{l/g}$. However, Huygens wanted a pendulum that would vibrate in exactly the same time no matter what the amplitude of the swing, and no matter if this might vary. A curve on which a pendulum will vibrate to meet this condition is called a tautochrone.

The Tautochrone. Huygens discovered that the cycloid is the tautochronous curve when gravity is the impelling force. His problem then was to devise a pendulum that would follow the cycloid. He was able to prove that the involute of the cycloid is a congruent cycloid. Now, an involute of any curve is the locus of any point on a taut string as it is unwound from the curve. This gave Huygens the solution of his problem for the perfect pendulum, at least, perfect in theory, a pendulum whose

FIG. 2

time of swing is independent of its amplitude. He fastened a weight to a string of the right length and suspended it between two blocks cut in the shape of a cycloid, thus constraining the vibrating weight to swing on a cycloid, the involute of the cycloidal blocks. Although the cycloidal pendulum satisfies Huygens' requirements for a theoretically perfect pendulum, it will not operate the mechanism of a clock, and Huygens soon concentrated on the circular pendulum which is quite satisfactory, even for clocks of great accuracy.

Suppose a cycloid is cut from a board and two balls are re-

leased on the curve at the same time, one at the top of the curve and one half an inch from the bottom. Although one may have many times as far to move to reach bottom as the other, the two arrive at the bottom of the cycloid at exactly the same instant, this being merely an application of the tautochrone property of the curve.

The Inclined Plane. A body falling freely under the impulse of gravity falls on a vertical straight line. In two seconds it falls four times as far as in one second; in three seconds it falls nine times as far as in one second, and so on. This law is expressed thus: the distance fallen is proportional to the square of the time of fall. The formula $s=\frac{1}{2}gt^2$ is the mathematical translation of this law. The question arises, is there some curve other than the vertical straight line of unrestricted fall on which a ball can roll and still obey the law stated above? The answer is *yes*. So long as the ball follows any straight line that is not horizontal it still obeys this law, but g must be replaced by a new constant that depends upon the angle of inclination of the line on which the ball rolls. The effect of an inclined line is to slow down the motion of the ball. The formula becomes $s=\frac{1}{2}kt^2$, k being less than g. The formula $s=\frac{1}{2}\sin\beta gt^2$ expresses the same fact, β being the angle of inclination of the line.

The Spherical Pendulum. Another natural question in connection with time curves is whether it is possible to construct a pendulum such that the weight moves at a perfectly uniform rate; this does not refer to uniformity of time for the beats but refers to the rate at which the pendulum swings while making a beat. Another way of stating the question is this: is it possible to make a curve or surface on which a weight can be restricted to move so that it covers equal distances in equal time intervals. The answer is yes, theoretically, at least. Let a rigid upright be fixed to a solid base and let a weight be tied by means of a length of string or chain fastened to the top of the upright. If the weight is started moving on any horizontal circle (not necessarily the circle whose center is the point at which the string is attached to the upright), it will move at a uniform rate. Under ideal conditions of a perfect vacuum, frictionless bearing and freedom from shock, the weight will continue to move at the initial uniform rate. This is called the *spherical pendulum*, the weight moving always on the surface of the sphere of which the point at which the string is fastened to the support is center.

If a ball is started rolling around the edge of a circular dish with level bottom it will approximate the conditions of a spherical pendulum. This is, of course, the spherical pendulum with the side of the dish substituted for the thread.

In this discussion the word ***pendulum*** has been used in its physical sense of a moving point, not in the mechanical sense of a device for regulating a machine for telling time.

AIN'T IT AWFUL!

DONALD COCHRANE, *Gibson's Landing*

Did you see what I saw, in *The B. C. Teacher* for January? It was an article suggesting that children should be promoted according to what they know, instead of according to age. Worse than that, the misguided writer wanted to restore the hateful official examinations, and give the children certificates that would actually mean something. He even mentioned the forbidden words, "selection" in the High School grades, and "retardation" of backward students in lower grades.

Surely he can be no true "liberal" or "democrat." He must be a "parafascist" (I saw the word in *The B. C. Teacher*, so it must be a good one. I guess it means any one who isn't a communist).

How can he hope to oppose the whole trend of modern education, which is to keep children in classes strictly according to age, and compel all to travel at the rate of the slowest? Doesn't he know that all striving and struggling, in fact anything that could be called work, is anti-social? He even thinks that anyone in Grade Nine ought to know the work of Grade Eight. He evidently has never fathomed the modern system of promotion, which is that the penalty for not doing the work of one grade is to be promoted to a grade where you can't do the work even if you wanted to, and from there, the next year, to a grade where you don't know what the work is about.

How dull it would be for the teacher, if all the children in his grade knew the work of the previous grade! He would lose all the stimulation of having to teach five grades at once. Doubtless all the city teachers would resign, and go teaching one-room country schools where they could meet a good range of intellect.

If we were to listen to this counter-revolutionary, he could probably demand reports that would let the parents know what their little darlings are learning in school, instead of keeping it a close secret as at present. All really modern teachers know that a child's grades should be based on his performance compared with his I.Q., and you must never tell the I.Q., so the parents can never know what the grades mean, if anything. The underlying philosophy is that the Programme of Studies is mainly rubbish, so it doesn't really matter whether the children learn it or not.

The basic fallacy of these ideas is in the outworn tradition that school is a place where children go to learn something. Not at all, Mr. Westmacott. "Education is life," and the business of life in school is to acquire attitudes and do enterprises. Don't spoil it by trying to teach them anything.

—*B. C. Teacher*

AN ODD LOCUS

A HYPOCYCLOID, SPECIAL CASE

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A circle rolls inside another circle of double the diameter. What is the locus of a point on the inner circle?

The idea of tracing paths of points, fixed on a circle, but moving because the circle moves, appeals to students, and most of them discover the ordinary cycloid as they watch a point on a moving bicycle tire. It is an easy transition from letting the circle roll on a straight line to letting it roll inside a larger circle. Normally, curves result. That is what makes this problem particularly interesting. One's intuition is likely to be false, the locus being a straight line instead of the usual cusped curve.

Consider the geometric solution.

Given:
Circle O, radius $2a$
Circle C, radius a
Circle C rolls inside circle O starting with P at A. P is a point on circle C such that $\widehat{AT}=\widehat{TP}$

To Prove:
P lies on diameter AOB

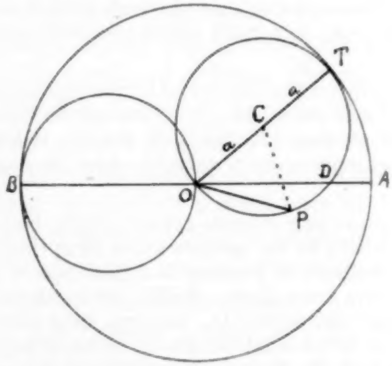

FIG. 1

Proof:

1. Assume P is not on AOB. Then D is the intersection of AOB and circle C. $\angle POC \neq \angle DOC$.

2. $\widehat{PT}=\widehat{AT}$	2. Given
3. $2\angle POC=\angle PCT$	3. Both equal to $\widehat{AT}$
4. $\angle PCT\cdot a=\widehat{PT}$	4. Length of arc equals $r\theta$
5. $2\angle POC\cdot a=\widehat{PT}$	5. Substitution (3 in 4)
6. $\angle DOC\cdot 2a=\widehat{AT}$	6. Length of arc equals $r\theta$
7. $2\angle POC\cdot a=\angle DOC\cdot 2a$	7. Substitution (5 and 6 in 2)
8. $\angle POC=\angle DOC$ This contradicts step 1.	8. Equals divided by equals equals.
9. P lies on diameter AOB	9. The assumption that P is is not on AOB is false.

Using the same hypothesis, the parametric equations representing the locus of P can be found.

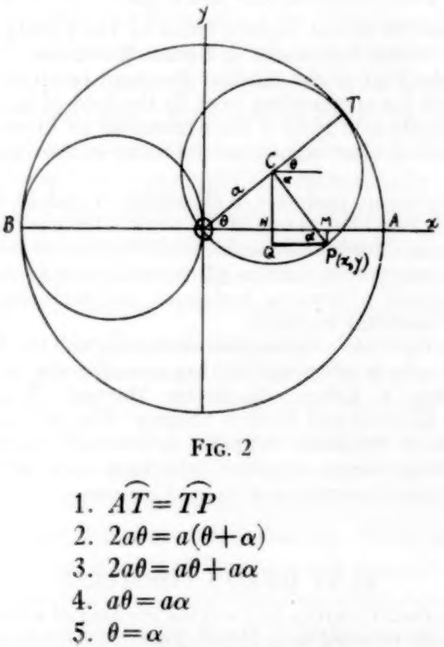

FIG. 2

1. $\widehat{AT}=\widehat{TP}$
2. $2a\theta=a(\theta+\alpha)$
3. $2a\theta=a\theta+a\alpha$
4. $a\theta=a\alpha$
5. $\theta=\alpha$
6. $x=OM=ON+NM$
7. $x=ON+QP$
8. $x=a\cos\theta+a\cos\alpha$
9. $x=a\cos\theta+a\cos\theta$
10. $x=2a\cos\theta$
11. $y=MP=-PM$
12. $y=-(QC-NC)$

13. $y = -(a \sin \alpha - a \sin \theta)$
14. $y = -(a \sin \theta - a \sin \theta)$
15. $y = 0$

These are the parametric equations of the diameter AOB. Therefore, the locus of P is a straight line segment.

Some high school students are capable of developing the geometric proof. Junior college students will like the analytic treatment, for the parametric equations give precisely the shuttle motion of the locus. But whether or not the refinements of this latter method are grasped, rare indeed is he who does not respond to the curious fact itself; namely, that the point travels so direct a route.

THE FRANKLIN MEDALS FOR 1947

The 1947 Franklin Medal, highest honor of The Franklin Institute, was awarded to Dr. Enrico Fermi and Sir Robert Robinson.

Dr. Fermi, physicist at the Nuclear Research Institute in Chicago, received the medal for outstanding work in the field of atomic energy. His immediate recognition in 1932 of the neutron as an atomic projectile has resulted in much of what science knows today of this important development.

Sir Robert Robinson, professor of chemistry at Oxford University, England, is generally regarded as one of the world's leaders in organic chemistry. He was honored for his invaluable contributions to the present knowledge of natural substances, such as plants and other living things. His recent investigations of pyrimidine analogues, and their relation to vitamin-B, has greatly benefited mankind.

The Franklin Institute's Committee on Science and the Arts, established in 1834, which selects all medalists, has awarded the medal in previous years to Thomas A. Edison, Guglielmo Marconi, Neils Bohr, Orville Wright, Albert Einstein and Harlow Shapley. The gold medal, which carries a medallion of Benjamin Franklin, is awarded annually to workers, regardless of their country or creed, who have done most to advance a knowledge of physical science and its applications.

IS IT HERO'S FORMULA?

The formula $A = s(s-a)(s-b)(s-c)$ for the area of a triangle in terms of the sides is usually referred to as Hero's Formula. However the attributing of the formula to Hero conflicts with the explicit attribution of it to Archimedes by the Arab, Albiruni, an author well informed and presumably in possession of works of Archimedes other than those which have come down to us. In these latter works the formula does not appear.

See an article by H. Suter in *Bibliotheca Mathematica* for 1910–11, pages 11 to 80 and particularly pages 39 and 40. For other references about the formula see J. Tropfke, *Geschichte der Elementar—Mathematik*, book 4, page 128; book 5, pages 46 and 86.

Contributed by NORMAN ANNING

THE VOCABULARY OF CHEMISTRY

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In the 1927 edition of *The Literature of Chemistry* by Crane and Patterson, p. 23, we read, "There has been in modern times no adequate general dictionary or wordbook of chemistry analogous to the medical dictionaries of Dorland, Gould and others—a book which gives the meanings of the large increasing number of technical words."

A statement of this sort naturally prompts the question, "What is being done to remedy this situation?" To which Crane and Patterson give the rather vague answer by making reference to the "Chemical Age" *Chemical Dictionary* and to Gardner's *Chemical Synonyms and Trade Terms* with the hope that chemistry will be served in the future in this direction.

Webster's *New International Dictionary* states that (1) a dictionary is a book containing the words of a language, usually arranged alphabetically, with explanations of their meaning and (2) a book containing the words belonging to any system or province of knowledge, arranged alphabetically.

In view of the fact that Webster's *International* contains an incomplete list of the words used in chemistry, it can hardly qualify as a dictionary of the English language according to the first definition; according to the second definition, no such dictionary exists in the English language. Students and teachers as well suffer a great handicap because of this gap in the libraries of organized knowledge. It should be pointed out that the editorial staff of Webster's *International* has the name of but one chemist, that of Austin M. Patterson. The *Oxford English Dictionary* in its 12 volumes and one supplement, while considered a masterpiece, is also woefully lacking in chemical nomenclature. The word aniline does not appear.

A word, by definition, is the smallest particle of speech that has meaning when taken by itself. The meaning of some words is so great that volumes must be written to adequately give their interpretation. A dictionary, then, must of necessity become encyclopedic to fulfill the requirements of the future. Rightly used it is the starting point for scholarly investigation.

It would appear that the German, the French and the British chemists have set the pace in the writing of chemical dictionaries. There is nothing up to date that has been contributed by

American chemists. The German dictionaries have been written mostly from the standpoint of industry while the French dictionary, by Adolphe Wurtz, is both applied and historical. It would appear that American chemistry is still very largely dominated by and dependent on European and British methods of approach. It must be confessed that the Oxford *English Dictionary* is still the outstanding dictionary in our libraries. All that the scholar desires to know about a word—its meaning, its derivation, its history, and its various uses may be found in this remarkable compilation, in which many American scholars collaborated. Best of all it is published in 13 volumes of convenient size and resembling a handbook. It would seem to be a model after which a dictionary of chemistry might be built. In the preface appears a diagram which indicates that the editors have included scientific and technical terms. Among the editors appears the name of Soddy, Eddington and others. In compiling the 1933 edition some 800,000 words were parcelled out to the different workers. Whether the contributions of chemistry for the past 100 years was included is problematic. Whether all of the chemical or scientific terms should be included in an English or American dictonary might be an interesting subject for investigation. The writing of the Oxford Dictionary has been in progress for over 100 years. Why should not this experience be enlisted by chemists in the solution of a very serious situation? The management of the Encyclopedia Britannica in Chicago, The Sears Roebuck Company, stated to the writer that in a short time all texts in chemistry would be dispensed with and that students would use the Encyclopedia solely in the study of chemical literature. It must be conceded that the chemical literature found in this Encyclopedia has been well written. But whether the editors of this stupendous compilation are planning to solve the chemist's problem for him is also problematic.

This matter of vocabulary and dictionary seems to concern the teacher more than it concerns authors and investigators. He must of necessity give the major part of his time and effort in teaching the chemical vocabulary to those who are to become the future leaders. It is a common criticism that the workers in chemistry as a class are woefully lacking in vocabulary. They seem unable to express thought either orally or in writing. This also casts a reflection on those who teach because it shows a lack of objective. It may also be pointed out that the cultured mind must be on speaking terms with some seventy to eighty thou-

sand words. That is going Shakespeare one better as he needed but 16,000 words, few if any being chemical terms.

Chemical terms have not yet been defined so as to make them intelligible to the lay mind. Science may well boast of having classified knowledge and of having contributed the scientific method, but to what avail is this classification if written in hieroglyphics as difficult for the layman to read and understand as were the hieroglyphics of ancient Egypt. It is true that chemistry speaks an international or a world language, but the fact must not be lost sight of that those who speak and understand this language composes a very small proportion of the world's population. Chemists have vision. They aim to solve problems not only for the present but for the future unborn generations. But the problem of making the experiences of the ages, as well as its knowledge, easily available to the present as well as to the future generations, is one of the tasks for the teachers of chemistry to wrestle with each day of the college year. Each individual acquires a vocabulary which is peculiarly his own. Yet he must also acquire a vocabulary common to the field of knowledge in which he elects to work.

The authors of dictionaries write definitions which may be understood by scholars and by laymen, except perhaps in the case of chemical terms. Whether this problem can be solved by any but the scholar is one of the many unanswered questions.

The invention of a language, together with an alphabet whereby it can be recorded, has been considered one of the greatest achievements of the human mind. The other phenomenal achievement of the mind is demonstrated when the ideas expressed by words can be flashed from one mind to another rapidly and accurately. As the orchestra can put beauty and harmony of tone into the souls of the listening audience, so may he who knows words and their proper use stir thought and will by the written or the spoken word. Some discouraged soul has remarked that "language was invented to conceal thought." Locke says, "Amongst men who confuse their ideas with words, there must be endless dispute." So might some of us conclude after spending a weary hour listening to a paper couched in terms unintelligible to untutored ears. Authors of such papers are all too prone to assume that the audience which they are to address is prepared to interpret words used in such addresses. In this connection diction seems not yet to have claimed a place in chemical writings. By diction is meant the

choice of words for the expression of ideas in discourse, with regard to clearness, accuracy, and variety. The chemist must so occupy his mind with the learning of words and more words that perhaps the possibility of developing a diction is quite impossible. Besides understanding the language of chemistry it is quite necessary to understand other languages, ancient and modern. Chemists gifted with phenomenal memories get on well with chemical vocabularies; also students who have a good foundation in language studies. But the handicap which confronts all students is a faulty background, either from the home or the public schools. If there is no language, mathematical or English background the teacher has no foundation upon which to build, and the expenditure of time and money seems to be sheer waste. The teacher of chemistry is compelled to deal with what in many cases is an impossible situation, yet students with a C− aptitude aspire to become chemists.

H. L. Mencken in his interesting book, *The American Language*, calls attention to the fact that at various times during the history of the country legislative measures have been introduced in the national congress and in several state legislatures to the effect that the American language should be adopted as the national or the state language. Illinois seems to have been the only state in the Union which has enacted a law establishing the American language as the language to be taught and spoken. The fact seems to have been lost sight of that during World War I there was also a language war to decide which language was to be the world language. While attending the Council of the League of Nations as a newspaper representative, I observed that only French and English were spoken, which I took to mean that these were the languages that won the contest. While politicians strive to make political merchandise out of language the chemist must not forget that he is a world citizen and must give attention to a world language. We have international committees on nomenclature, on atomic weights, on classifications; it is quite evident that we should have an international committee on vocabulary. A few years ago the American Chemical Society sent out a list of some 400 words for the purpose of determining their conventional pronunciation. I have a copy of the findings of this study which I find indispensable. Why could not a beginning be made in the same way for a chemical dictionary? During a world crisis the national government calls upon its scholars and its scientists, whether they are in the employ of

educational institutions or of industry, to join in the solution of vital research problems under the direction of government. During this last global struggle the accomplishments of such cooperative research has approached the miraculous. The scientists of the nation are now clamoring for a continuation of this type of cooperative research as a protection against any aggression which may be attempted in the future, as well as an assurance that the high standard of living of the nation shall not be lowered. All of this effort largely pertains to the physical and the material welfare of the nation which is right and good. But the question arises, and will persist, as to whether languages and nomenclature is a national problem or whether it is to be long to an unclassified group of scholars and writers. The Library of Congress has instituted a method of classification for all branches of knowledge, which has been adopted by many libraries over the land but not by all. The city library of St. Paul, Minnesota, uses the Library of Congress classification but the city of Minnespolis and the State University of Minnesota employ the Dewey system of classification. It would be a logical conclusion that the Library of Congress would take the initiative and build a comprehensive and all inclusive dictionary of the American language. Instead a group of scholars at the University of Chicago has assumed this task of compiling a voluminous dictionary of American English. The dictionary is the oldest as well as the most fundamental book of classified knowledge. In the library of the University of Florida I discovered a dictionary with the name "Lexicon Tetraglotten," an English-French-Italian-Spanish dictionary whereunto is adjoined a large nomenclature of the proper terms (in all four) belonging to the several arts and sciences, to recreations, to professions both liberal and mechanical, etc. The dictionary is divided into 52 sections, each of which presumes to contain all of the known nomenclature of the four nations in the year 1660 when the dictionary was compiled in London by Samuel Thompson. Section 48 has listed the chemical nomenclature. There are but 4 pages with two columns to the page. None of the terms have survived to the present day. It reveals to one in a very vivid way that the graveyard of obsolete and incorrect terms of nomenclature must be enormous. It brings forth the fact that science both buries words and creates words as the newer knowledge displaces the old. It also reveals the genius of the English nation to not only rule or encompass the earth but also to engulf all of

the known knowledge of the four leading civilizations of the earth. It was an early pattern for a dictionary and like the King James Version of the Bible was fostered by His Majesty the King of England. It raises the question as to whether science in general or chemistry in particular has any pattern for the writing of dictionaries? If there is a pattern whose responsibility is it? Is it the obligation of the ACS or of the Bureau of Standards? The Chemical Abstracts religiously scans the pages of the scientific world and has developed an excellent method of indexing. But Chemical Abstracts is neither a dictionary nor an encyclopedia. Few students in beginning chemistry ever learn to use its ponderous volumes.

SCIENCE TALENT SEARCH SCHOLARSHIPS AWARDED

For the sixth year, 40 high school seniors, recognized for possessing "an unusual science potential," have been awarded scholarships to help them continue their scientific and engineering educations. The awards were made March 4 at Washington to finalists in the annual Science Talent Search, the nationwide activity conducted by Science Clubs of America through Science Service and supported by the Westinghouse Educational Foundation, which is maintained by the Westinghouse Electric Corporation.

Top awards, four-year scholarships of $2400 each, went to a boy from Massachusetts and a girl from Long Island, both 16. They are Martin Karplus of West Newton, and Vera Radoslava Demerec, of Cold Spring Harbor, New York.

Karplus, who plans to enter Harvard, major in biology and then devote his life to medical research, stands first in a class of 750 at Newton High School, Newtonville, Mass.

Miss Demerec plans to enter Swarthmore to study zoology and then make a career of museum work. She is ranked among the top students in a class of 185 at Huntington High School.

Eight of the 40 finalists from 15 states and the District of Columbia, who competed for $11,000 in Westinghouse Science Scholarships, were awarded $400, four-year scholarships.

A MATCHBOX SIZE CAMERA

Eastman Kodak Company recently disclosed the story of how it had secretly designed and built 1,000 tiny cameras of matchbox size for use by the OSS and underground forces during the war.

Small enough for concealment in a person's hand, the camera was yet capable of snapping pictures about one-half inch square that could be enlarged many diameters and still retain their clarity.

In addition to the cameras, Kodak also supplied OSS with "vestpocket darkroom" kits containing several rolls of 16 mm. film, photographic developing and fixing chemicals in pill form, a small chamois for wiping the developed film dry, mixing spoon, film clips, and a pencil-size solution agitating stick.

NOMOGRAMS

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Nomography is the art of representing a mathematical law in pictorial form. The individual representation is called a nomogram. It will be our purpose in this paper to study a nomogram representing a simple mathematical law from physics, to understand the theory behind its construction and to use it as a guide for suggesting ways of constructing other nomograms.

The theory required in the design of most nomograms is so simple that it may be easily understood by a beginning student in mathematics. It is hoped that the reader may be stimulated to construct nomograms for other mathematical laws.

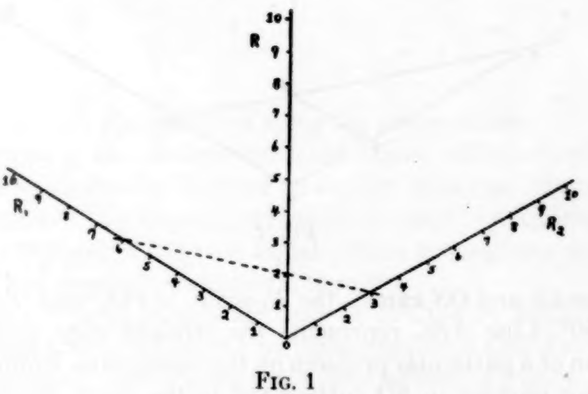

Fig. 1

Nomogram: $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}$

Let us look at a nomogram which pictures the mathematical law for the combined resistance formed by two resistances connected in parallel in an electric circuit. The law is

$$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}. \tag{1}$$

A nomogram for this law is given in Figure 1. To use this nomogram to find the combined resistance due to resistances of 6 and 3 ohms connected in parallel, place the straight edge on 6 on the R_1-scale and on 3 on the R_2-scale and read 2 ohms where the straight edge cuts the R-scale. This is the numerical solution of the equation

$$\frac{1}{R}=\frac{1}{6}+\frac{1}{3}.$$

The three quantities R, R_1, R_2 satisfying equation (1) are seen to lie along a straight line cutting the three scales of the nomogram in Figure 1.

This nomogram replaces computation with fractions in which it is easy to make clumsy errors. The results may be read with the same accuracy as the scales of the nomogram itself.

A study of Figure 2 will show the mathematical theory of the nomogram in Figure 1. Line OP carries the R_1-scale, OQ carries

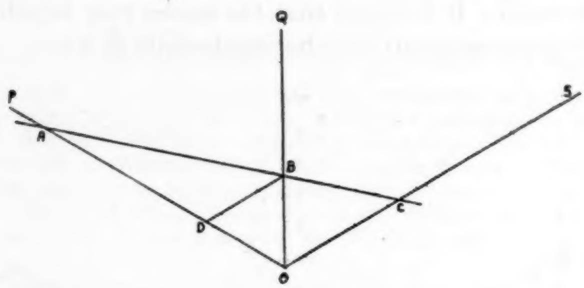

FIG. 2

the R-scale and OS carries the R_2-scale. $\angle POQ$ and $\angle SOQ$ are each 60°. Line ABC represents the straight edge used in the solution of a particular problem on the nomogram. From B a line is drawn parallel to SO cutting OP in the point D. $\triangle ADB$ is similar to $\triangle AOC$. Hence

$$\frac{DA}{OA}=\frac{DB}{OC} \tag{2}$$

and $DB=OB=OD$ since $\triangle DOB$ is equilateral. Therefore (2) becomes

$$\frac{OA-OB}{OA}=\frac{OB}{OC}$$

or

$$1-\frac{OB}{OA}=\frac{OB}{OC}$$

whence

$$\frac{1}{OB}=\frac{1}{OA}+\frac{1}{OC}\cdot$$

If OA measures R_1, OC measures R_2 and OB measures R we have the nomogram shown in Figure 1.

If, instead, OA measures p, the object distance; OC measures q, the image distance; and OB measures f, the focal length of a lens; then we have a nomogram for the familiar lens formula

$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q}\cdot$$

In general, this nomogram will illustrate any mathematical law which may be reduced to the form

$$\frac{1}{x}=\frac{1}{a}+\frac{1}{b}$$

provided x, a, b are measured along the proper scales.

A review of the theory discussed above will show that the nomogram illustrated is based on similar triangles. Many other nomograms of this same type may be devised by requiring only that $\angle POQ$ and $\angle ROQ$ are equal. These nomograms are more general but require no additional theory.

Another type of nomogram may be devised by replacing the concurrent scales of Figure 1 by three parallel scales. The theory underlying this type of nomogram may be seen in Figure 3.

Lines PP', QQ', RR' are constructed parallel to each other and such that QQ' is midway between PP' and RR'. Let AC and DF be transversals of the three parallel lines. Construct DH parallel to AC. Then $\triangle DGE$ and $\triangle DHF$ are similar. Hence

$$\frac{HF}{GE}=\frac{DH}{DG}$$

but

$$HF=CF-CH$$

$$GE=BE-BG$$

$$AD=BG=CH$$

$$\frac{DH}{DG}=2.$$

Hence

$$\frac{CF-AD}{BE-AD}=2.$$

Therefore

$$2BE=CF+AD. \tag{3}$$

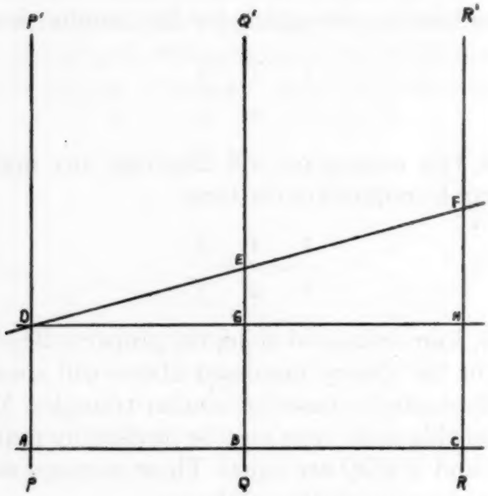

FIG. 3

Any law which may be written in the form $z=x+y$ may be represented on a nomogram of three equidistant parallel scales as in Figure 3 if we let

$$BE=\tfrac{1}{2}z,\ CF=y,\ AD=x.$$

As an example of this type let us construct a nomogram to represent the product law $w=uv$. This may be done by taking the logarithm as $\log w=\log u+\log v$. Now let

$$2BE=\log w, \qquad BE=\tfrac{1}{2}\log w.$$

$$AD=\log u, \qquad CF=\log v.$$

This nomogram is shown in Figure 4. To multiply 2 by 3 place ruler on 2 on u-scale, on 3 on v-scale and read 6 on w-scale.

To use it for division place ruler on dividend, say 8, on w-scale and on divisor, say 2, on u-scale, then read quotient 4 on v-scale.

An interesting extension of this type of nomogram may be obtained by varying the ratio AB/BC in Figure 4. The effect of this may be seen immediately in equation (3).

Mathematics classes may find it profitable and instructive to construct simple nomograms. Nomograms may provide an interesting project for mathematics clubs.

Those who wish to explore nomography further are referred to the bibliography at the end of this paper. These books not only cover the theory adequately but also give illustrations of hundreds of nomograms which may be constructed.

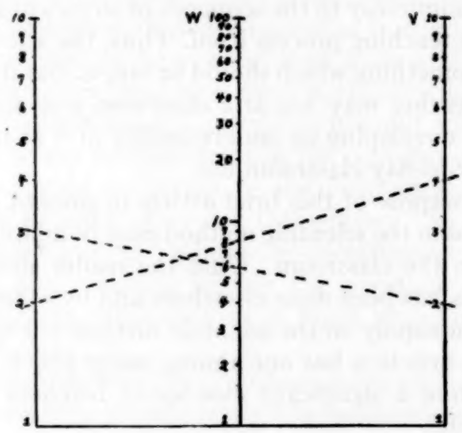

FIG. 4
Nomogram: $w = uv$.

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The esteem in which teaching and education are held by the American public is found in these comparative expenditures for education: Prior to the war we spent about 3 per cent of our income on public education. In 1946 we spent 1.4 per cent, the lowest in history. Today our annual cost for public education is $17 per person; for tobacco, $19 per person; for alcohol, $51; and for cosmetics, $15.

—EDGAR DALE

THE SCIENTIFIC METHOD AS A TEACHING PROCEDURE

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Much has been said, and many good articles and books have been written about the scientific method and the ways of thinking and behaving which are associated with it. So too has the teaching of the scientific method long been recognized as one of the objectives of science education. In recent years it has gradually become evident that the steps in the scientific method lend themselves admirably to the sequence of steps which may be followed in the teaching process itself. Thus, the scientific method is not only something which should be *taught*, but it is something which the teacher may *use as a classroom procedure*, using the method and developing an understanding of it at the same time through day-to-day classroom use.

It is the purpose of this brief article to present an outline of how the steps in the scientific method may be adapted to teacher procedure in the classroom. (And the reader should make no mistake; this has been done elsewhere and by others before. No man has a monopoly on the scientific method nor upon its application. This article is but one among many which must be contributed before a significant number of teachers begin to use this approach.)

Good teaching begins with (or stimulates) interest in a problem of significance and importance to the learner. According to the psychology of learning there is no learning without motivation, without a need. Learning itself is essentially problem solving. The scientific method then begins at the same point—with a problem. Let us note this and the succeeding steps in the scientific method and then examine their adaptability to classroom procedure.

The steps in the scientific method, in order, are generally deemed to be:

1. Recognizing a problem; defining it and stating it clearly.

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2. Suggesting a tentative hypothesis for solution of the problem.
3. Planning a course of action, properly involving controlled tests, to test the hypothesis proposed.
4. Carrying out the plan; collecting the facts of observation.
5. Organizing and analyzing the facts collected.
6. Drawing conclusions and inferences with respect to the hypothesis; proposing generalizations.
7. Applying the generalizations to new situations.

Let us now take the steps and follow them in a teaching-learning situation in the classroom to see how well they apply.

STEP 1. *The problem.* Teaching-learning problems arise best out of the environment of the learner. Every pupil question is a potential problem for study. The teacher, however, must select wisely those problems which are related to learner's mental age, maturity level, and background of experience and need. Let us say that the teacher, sensing a need in the area of health education, accepts for attention a problem brought out in class discussion, and writes the statement of the problem on the blackboard. This should be stated in the form of a question, as: "What made so many of us sick this winter?" As a question it provides a good lead and a basis for investigation, and the results of the study should answer the question. The teacher should have such considerations in mind throughout the succeeding steps.

STEP 2. *The hypothesis.* A hypothesis is merely a guess answer for our purpose here. Scientists must be imaginative in proposing solutions. It must be clear that the guesses are to form the point of attack for the investigation which is to follow. In the classroom the teacher asks the pupils for their ideas, possibly listing these on the blackboard, noting carefully that they are *guess answers.*

Enough discussion to stimulate interest is very effective here. So much discussion that a pupil develops an emotional interest in the answer which he proposes, and then feels that he must defend it against all odds or all evidence, however, is neither wise nor effective.

Another valuable function of this discussion and period of guess answers is to provide the teacher with an insight into what the pupils already know and think about the problem to be studied. Generally pupils will give rather adequate answers to the problem stated above, but such guess answers (hypotheses) as the following may be forthcoming:

We were bad. We ate poor foods. We did not live right.

We went outside with too few wraps. Our "systems" were upset.
We "caught" the sickness from others. Germs got in us.

These make an excellent list for attack upon the problem.

To more difficult questions, of course, less adequate guess answers will be proposed.

STEP 3. *Planning the investigation.* After the class has proposed various answers the teacher's next leading question should be, "How can we find out?" We hear much of *teacher-pupil planning*. This is the point at which it becomes operative. Together the teacher and pupils plan to visit the local clinic or school nurse's office, send a delegation or an individual to interview a physician, nurse, or health officer, write to the board of health for information, read in science and health books of appropriate reading levels, read the newspapers and current periodicals, ask parents, order and watch (and listen to) movies, and plan to raise some micro-organisms by puncturing an apple skin, sneezing on agar plates, or doing other things appropriate to the age, grade, mentality, maturity, and experience levels of the group.

STEP 4. *Carrying out the plan.* The step of conducting the activities is now at hand. We hear much of activities, and these activities will be carried on, not for activities' sake, but for the sake of finding answers to our question. All the above activities may contribute valuable information.

It must be recognized by the pupils that all findings must be carefully recorded and reported. All facts must be handled in an objective manner, possibly kept in a notebook for later reporting. The pupil properly motivated to be "scientific" may take great pride in being precise and accurate, when at other times he may be slipshod and careless.

Another instructional challenge will have been met too by the wise teacher who utilizes activities of varying difficulty levels to provide for the individual differences within the group being taught.

STEP 5. *Organizing and analyzing the facts collected.* During this stage the pupils, under the guidance of the teacher, will be sharing their fact findings with others. What did each individual or committee find? Where was the information obtained? Is such a source reliable? Was a direct study properly controlled?

Care and tact must be exercised here lest Uncle Looie's pet explanation as reported by his young nephew be treated in such a way that Uncle Looie is placed in a position of ridicule or disrepute. Skillful guidance, however, is the teacher's role, and the

good teacher will play it effectively. Related facts will be placed together. Conflicting findings will be examined for source and reliability. Order and organization will be brought out of the welter of collected data.

STEP 6. *Drawing conclusions and inferences, and proposing generalizations.* This is a crucial step in teaching and learning. Too often teaching and learning stop with the preceding step, the mere acquisition of facts. Interpretation of those facts, however, with the answer pointed to the "so what" of the facts, their meaning and interrelationship, is the significant step in building understanding in the minds of the pupils. This cannot be overemphasized. Any drill to assist retention must follow this understanding, not precede it. It is from such generalization that the big ideas arise in the minds of the pupils.

Pertinent generalizations might now be listed on the blackboard under the question that has remained in a conspicuous place throughout the work on this problem. Such broad generalizations must be stated in the form of declarative sentences, not as brief phrases or as isolated words. Such statements as the following might be set up by the pupils with teacher help:

> Many small living things may get into our bodies and make us sick. These tiny disease-causers may be spread by sneezing, coughing, or by drinking impure water or eating dirty food. We get sick from the poisons which such germs give off into our bodies. Some germs eat the living parts of our bodies. We cannot resist germs as easily when our bodies are tired, poorly fed, or exposed to unusually cold or damp conditions.

Bear in mind, of course, that the nature of these statements must be dependent upon the level of the group involved.

STEP. 7. *Applying to new situations.* We now arrive at the crucial *test* of our teaching. If the teaching has been purely verbal the pupils may write wonderful exams but still exchange used chewing gum. Possibilities for transfer to real situations must be pointed out whenever possible. We must not expect transfer (carry-over) to be automatic and perfect. Long established home habits may have to be broken down. Prejudice and superstition may still play a part in determining the behavior of the pupil. Only through long and continued effort and interpretation of the child's experiences can progress be made.

At this point the openmindedness of the learner is particularly challenged. The teacher needs to point out this important challenge to one's behavior, and note that openmindedness is

one of the scientific attitudes most essential in profiting from scientific discovery. Science reaches its greatest heights when its findings are not merely considered valuable in and of themselves and are thus stored in the archives, but rather when its findings are utilized for better living and greater happiness for the individual among all men. A thousand facts of health are valueless to the girl who shares the lollypop of a tubercular friend. Knowledge of the life cycles of any number of parasites is not functioning in the life of a college boy who eats raw hamburgers!

A Method Worth Trying

For the professional teacher, always alert to possibilities of improving instructional practices, always on the alert for a method which will really "click," the above method is strongly recommended. Results will be inspiring and gratifying. The writer has seen long experienced teachers adopt it effectively, and has seen student teachers use it with success and satisfaction.

For science teachers particularly this method holds great possibilities, for science teaching has long ago adopted the responsibility for teaching the scientific method as one of its objectives. Application of this procedure is not limited to the field of science teaching, however. Here is an approach which will teach the scientific method in any field while it is actually being used. Identify the steps and share them with the pupils. Bring into education that method of problem solving which has brought about the great material and scientific progress of our age, and possibly sometime, if indeed there is yet time, we may be able to bring man's social problem solving abreast of his undisputed efficiency in the areas of natural science investigation.

KEEN-EYED ASTRONOMERS IN CZECHOSLOVAKIA SPOT TWO COMETS WITHIN A YEAR

Keen-eyed astronomers in Czechoslovakia have spotted two comets within a year. Comet Becvar, now speeding away from the pole star and heading south, is the second comet found recently at the new modern astrophysical observatory near Skalnate Pleso (Rocky Lake) in Czechoslovalia. It was spotted by Dr. Antonin Becvar, who during the war persuaded the Slovak government to erect the observatory at this spot 6,000 feet above sea level.

Late last May a sixth magnitude comet was found by Ludmila Pajdusakova, also of this observatory. The comet was independently discovered by David Rotbart, Washington business man, so is known as the Pajdusakova-Rotbart comet.

THE TEACHING OF LABORATORY WORK IN HIGH SCHOOL PHYSICS*

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This paper presents the evolution of the laboratory teaching procedures used by the physics teacher that I know best.

This particular person began his work several years ago in a school system which then operated on a 45 minute period basis. Therefore, physics was scheduled to meet for single periods three days and for double periods, known as laboratory periods, two days each week.

The textbook and laboratory manual had been previously adopted, equipment and supplies were on hand, school opened, and this teacher worked hard seven periods per week with each class.

He had just left the university; he knew some of the rudiments of physics and had the good fortune to be well acquainted with all of the physical equipment to be found in this laboratory. Three days per week he held class. The principles of physics were seriously discussed and demonstrated. Two days each week the laboratory manual of physics became the guide. One day he would have the class do experiment six and the next, experiment seven. He held laboratories during 18 of the 20 weeks of the semester and his students performed 36 experiments.

It was impossible to keep the work of the laboratory exactly in step with the class work; so, although there was some connection, each experiment became, in effect, an end in itself. The students read the manual, did what it said a line at a time, filled in the blanks one by one, talked about irrelevant things while the experiment was "cooking," and when the last blank had been filled in the report was torn from the manual and handed in. Another experiment was done. The process had been purely mechanical; thinking was at a minimum. In spite of this handicap, some students learned considerable physics and some even learned something of the scientific method of problem solving.

By the next year this teacher was beginning to realize that laboratory periods should not be the product of arbitrary

* Read before the Physics Section of The Central Association of Science and Mathematics Teachers at Detroit, November 29, 1946.

scheduling but should be the outgrowth of a need on the part of the student to work on problems related to ideas which were being discussed in the classroom. There was no attempt at originality as to problems, for the laboratory manual was adhered to, but there was some discretion shown in the choice of "experiments." The problem was chosen because it appeared in the laboratory manual, but not all problems appearing in the manual were chosen.

During this year some of the more interested students began to come in to the physics laboratory after school hours. They were interested in working with this or that piece of apparatus or in trying something which they had read about in *Popular Science*, *Q.S.T.*, or other sources. These students were always welcome and the teacher became engrossed in helping them with their special interests. He noted that many of the problems which students wished to investigate grew from their experience in the classroom and from their reading of the text and supplementary materials. He encouraged these students to delve into their problems and aided them with apparatus and procedure difficulties. The only change he made in his regular laboratory procedure, however, was to use some of the double periods for class discussion and the solution of mathematical examples whenever the "experiment" in the manual did not fit the proceedings of the classroom. This left fewer periods for actual laboratory work and experiments to be performed were chosen more carefully to fit into the total picture.

At about this time there was an administrative change in the scheduling of classes. Periods became 55 to 60 minutes long, and the science classes were restricted to five periods per week. The teacher first thought that 55 minutes was too short for a functional laboratory period, but experience led to a reversal of this opinion. Of course, the shorter period required the teacher to revamp all of the experiments which he had been using for they now had to be prepared for an hour instead of an hour and a half period. The five period week led to greater freedom from the bonds of the "cook book" which was being used as a laboratory manual. The laboratory periods could now be scheduled on any day of the week and the laboratory process made an integral part of the teaching procedure. Some physics concepts were *now* taught *solely* by means of laboratory study. This, at times, called for several days in succession in the laboratory. The ratio of time spent in the laboratory to that spent in class recitation

remained about the same as had existed in the seven period week, but laboratories were now scheduled to meet a teaching need.

I realize that such a plan requires freedom on the part of the teacher to use either laboratory or classroom facilities on any day of the week. This is not possible even today in some of our schools but will become increasingly more possible as our buildings are remodeled or new buildings are constructed, for the trend today is to plan every science room as a combination classroom-laboratory.

These years of experience and study led the teacher to see that students lacked the *functional understanding* of physical principles, although they could pass tests indicating a rote knowledge of the fundamental principles; they could quote the concept but could not apply it. It became his firm opinion that the only way to insure functional use of physical principles was to provide experience in their application coincident with the advancement of the student in his knowledge of fundamental physics. He could sense the student's need for practice in finding a problem in a situation and for isolating this problem sufficiently to formulate a clear statement of his query. This procedure when put into practice placed the laboratory manual in quite a different light. Instead of accepting problems for laboratory solution because they had been stated in advance by the author of the manual, the classes began to formulate their own problems for solution in the laboratory. In the evolution of this process, many manuals were kept in the laboratory for reference; and once a problem was formulated, the manuals were studied to find a satisfactory method of solution applicable to the equipment and supplies available.

In general, the class was kept on an "even front" basis in the laboratory, as earlier, but the solution of a given problem might be attempted with any or all of the several methods suggested in manuals being used simultaneously by different groups of students. Often ideas gained by the perusal of several manuals led students to use a modification of some method.

The laboratory report was no longer prepared by the filling in of blanks in the manual, since the student now possessed no manual. Instead, the student prepared his report on $8\frac{1}{2}'' \times 11''$ plain or ruled paper. More will be said about the report later.

It was noted that conversation in the laboratory adhered more closely to a discussion of the problem being solved. Stu-

dents using one method of solution would watch with considerable interest those using another method. The improvement which was noted in general laboratory attitude and in the questions which students asked the teacher prompted him to study his procedures further.

He concluded that the student must be provided sufficient experience in the use of the scientific method to insure the ability to apply this method to problems outside the classroom; that students learn by doing, and that the facilities of the laboratory are particularly essential to the doing. The problems to be solved by students in the laboratory must be of interest and be real to the students working in that laboratory. Therefore, more attention was given to the recognition and isolation of problems either indirectly or directly expressed by students, as well as to the clarity of the statement of such problems.

In a class where the effect of pressure on the temperature of the boiling point of water was being discussed, someone wondered whether the covering of a stew pan with an ordinary lid would cause sufficient change in pressure within the vessel to effect a change in the temperature of the boiling point. The teacher might have answered that the difference produced in the pressure would depend upon the fit of the lid and that best results would be obtained by using a pressure cooker. A curve plotting the temperature of the boiling point against the pressure sustained at the water's surface might have been introduced. That is, the query might have been met by the teacher's simply *telling* the student the answer. In this case, however, some discussion on the part of students under the guidance of the teacher led to a clearly defined problem, namely, "What effect will pressure changes brought about by placing the lids on our ordinary kitchen utensils have on the temperature of the boiling point of water?" A variety of such utensils, including a pressure cooker, were brought out. The lids were punched to admit a stopper and thermometer. The students thus investigated a simple problem which, to the teacher's knowledge, had not been presented in a laboratory manual, but which was of definite interest to the class members.

This problem led to another, which was simultaneously investigated, namely, "How will the presence of the lid affect the time required to cook a potato?" Cubes of potato were carefully prepared from similar stock and while one cube was permitted to boil in an open vessel, another was placed in a closed vessel.

After seven to twelve minutes of cooking by boiling, dependent upon the size of the sample, an examination was made to determine the extent to which each potato was cooked. The conclusion of the class group was that the cover had to fit very closely in order to maintain a sufficient increase in pressure to effect a noticeable change in the temperature of the boiling point or in the time required to cook the potato.

Results such as this, which appear in a sense to be negative, are just as important to functional understanding as are positive results. Further observation resulted in a positive conclusion concerning the use of even a loose-fitting lid, namely, that much of the steam which resulted from the boiling of the water condensed on the lid and dropped back into the vessel whereas the steam escaped from the open vessel. This observation was supported by a check on the initial and final weight.

A problem which each class was almost certain to raise came at the time when friction was being studied. Questions such as "What is the coefficient of friction between an automobile tire and the road?", "Is the coefficient of friction between the tire and road the same for a smooth tread as for a new tire?", "What effect does a wet pavement have on the coefficient of friction between a tire and the pavement?" were brought up. Some of the students made a concrete slab about eight inches wide and four feet long. One side was crossbrushed with a broom to produce the kind of finish found on our concrete highways. After the concrete had set the surface was rubbed vigorously with a paving brick to produce the effect of wear on the road surface. A section of smooth tread and a section of new tread, each about fifteen inches long, were obtained. A twenty-five pound lead weight was poured to fit the inside of the tire sections. The coefficient of both static and kinetic friction was determined for the two tread conditions for both wet and dry pavement.

It should not be concluded from these examples that all laboratory problems were of a consumer nature, but this teacher found student interest to be higher when the apparatus used was chosen from the student's environment and when the problem was one in which the student had a personal interest. The idea of mechanical advantage, for example, was of much more interest to students when various types of automobile jacks, commercial rope and pulley sets, and other simple but practical machines were used.

Students were continuing to come into the laboratory at the end of the school day to pursue problems of special interest related to physics but not necessarily related to the particular topic of immediate study. These students worked through a wide variety of projects from the modulation of a light beam with an audio frequency to the making of an X-ray examination of the hand or other object. The X-ray equipment was of the cold cathode type and had been presented to the laboratory by a doctor who was retiring. A teacher who is alert to the possibilities may obtain much valuable and practical material for his laboratory from the surrounding community. The after-school projects quite often had their origin in the class discussion and were usually of a type requiring more time than the regular laboratory experiment. Many of the results of this type of student work were used as demonstrations in the recitation period at the time when the particular concept was being studied.

In the evolution of the laboratory procedure used by this teacher, he had now developed a method which had entirely eliminated the use of a laboratory manual. The problem to be considered had its origin in the classroom as the various concepts of physics were considered. The teacher obviously had to provide much guidance and be most alert for original queries hinted at or directly expressed by students. The problems to be solved in the laboratory had to be chosen in terms of available apparatus and the time required for solution. Naturally, only a few problems could be solved in the student laboratory; many were attacked by class demonstration and by reference to the work of others as presented by the text and supplementary materials. A problem to be solved in the laboratory was isolated and its statement prepared through class discussion. The possible means of solution were considered by the class with the guidance of the teacher. Apparatus and supplies which would be needed were brought out and each piece, as well as the composite "set-up," was studied. In other words, students were getting a clear picture of the problem to be solved and of the methods and equipment to be used for the solution. They were thinking of the elements of the problem and at the same time of the problem as a whole. When these students began their laboratory procedure they had only their class notes and the idea—they did not have a laboratory manual to be filled in blank by blank. These students had to see their way through the

experiment from the beginning to the end. They talked principally about what they were doing. Most of them were interested in the experiment for the problem had had its origin in their classroom. Of course, this problem was not necessarily new to the world, but it was new to these students and it presented a new experience in its solution.

Data were obtained and checked against that which had been obtained by others where this was possible. That is, where the problem involved the determination of some physical constant the data could be checked; if it involved the mechanical advantage of an automobile jack, then one could check only against his computed value of the theoretical mechanical advantage obtained by measurement of the component parts of the jack.

The preparation of the laboratory report presented an opportunity for students to analyze their method of solution and to express themselves clearly and accurately. To require a report with equal emphasis on each of its elements for every experiment would be to require so much work of the student that he would become disinterested in the problem before he had completed his report and would again become mechanical and simply prepare something that he hoped would be acceptable to the teacher. To overcome this difficulty, the emphasis on individual elements of the report was varied with each problem and determined at the time the problem was established.

In every case a clear statement of the problem was essential. The statement of procedure which followed was varyingly emphasized. Sometimes only a diagram was used and at other times an essay type discussion of the procedure was the focal point of the report. Data was almost always reported in a tabular form which included space for the intermediate and final calculated results. The type of tabular form which would most effectively present this information was always emphasized and much skill was gained during the year in its preparation.

The calculations shown were typical of those necessary in the treatment of the data, but duplicate calculations were not presented. The discussion of the physical principles and of the interpretation of the data usually involved an essay type of treatment, supported where possible by a graphical presentation. This part at times received maximum emphasis in the written report, and at other times was handled by means of class discussion following completion of the experiment. Emphasis was also

varied on the written discussion of the possible sources of error and the computation of the per cent of error. In all cases each component part of the report was thoroughly treated either in the written statement or in the classroom.

During the course of the year the student gained skill in the application of the scientific method to the solution of problems of interest to him. His individual reports emphasized various elements of the application of this method to the solution of the problem, but by a variation in the emphasis the preparation of the report did not become such a burden as to become mechanical or monotonous.

The purpose of this paper has been to stress the need for leaving the mechanical procedure encouraged by a "cook book" type of laboratory manual, which has sometimes dominated, for a laboratory procedure where

(1) the problem is the result of thinking of students,

(2) the problem is both practical to and of interest to the students.

(3) the scientific method involving the isolation and careful formulation of the statement of the problem, the recall of experiences which bear upon the solution of the problem and the selection of an appropriate plan for the solution, the carrying out of an unbiased investigation and the formulation of a conclusion based upon substantial evidence, is consciously applied to the solution of the problem,

(4) students are provided the opportunity and encouraged to investigate larger problems of special interest to them by being provided the use of the laboratory facilities and the counsel of the teacher at times beyond those regularly scheduled for the class,

(5) the number of problems considered is not so important as the method used in the solution of each problem.

Our purpose, then, is to provide a laboratory procedure where students *think*, think in a way that science has found effective in the solution of problems—any problems, scientific or personal.

The days of economic servitude and insecurity for teachers must be brought to a close. Teachers must have public respect, professional earning power, and economic security. They must be able to afford professional study, books, travel, and other means of enriching their minds and renewing physical strength to meet the heavy and exacting daily tasks of the classrooms.

TECHNIQUES OF OUTDOOR EDUCATION

II. HOW TO MAKE A KEY

William M. Harlow

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A key is one of the most useful devices for teaching the identification of plants or animals. More than this, a good key develops the powers of observation, and discrimination, while from the student's immediate viewpoint, a key fitted to his level of development is "a lot of fun." Although excellent keys are available, most of them use an abundance of technical terms, and also include large numbers of species not found on the school ground or at camp.

Teachers should learn how to make simple keys to the natural objects of their own locality, and introduce them in the spirit of the treasure hunt or in the manner of the detective following clues. Teachers at the St. Mary's Lake Camp Association in Battle Creek, Michigan have been especially successful recently with this method of exploring the outdoors.

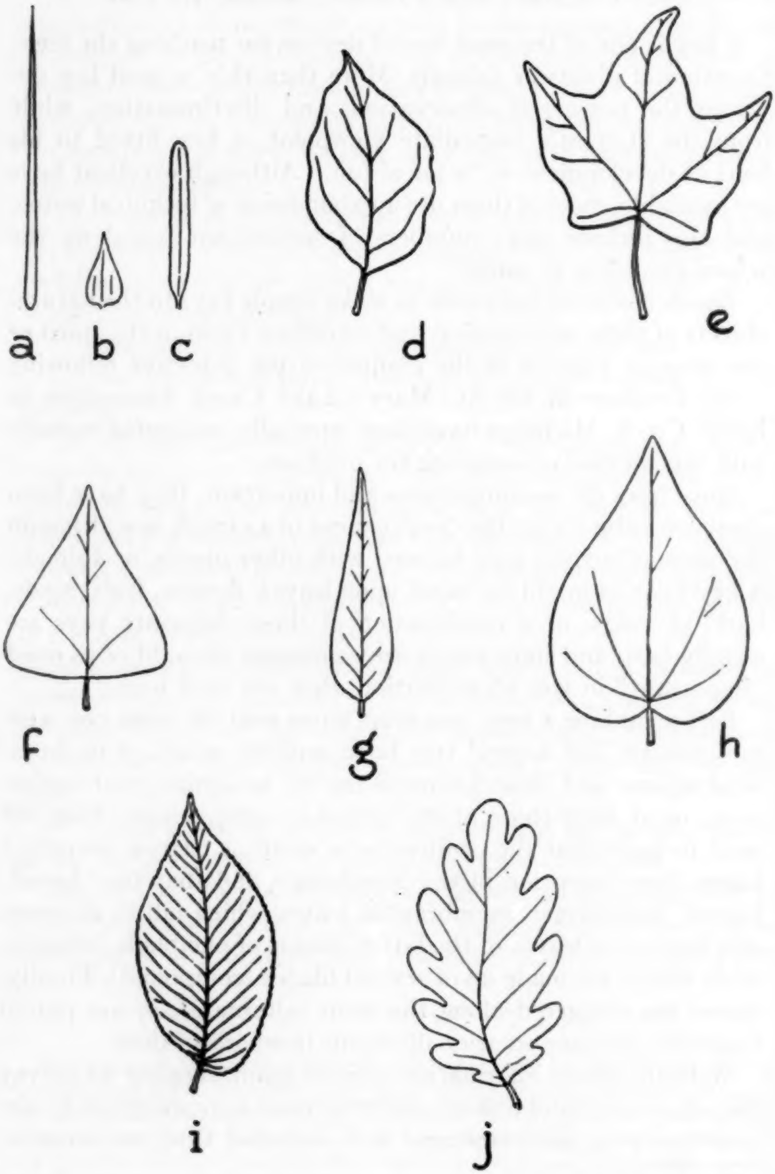
Since trees are so conspicuous and important, they have been chosen as subjects for the development of a sample key although the same principles may be used with other plants, or animals. A key to trees might be based upon leaves, flowers, fruit, seeds, bark, or twigs, or a combination of these. Separate keys are usually best, and since leaves are commonly thought of as most "important" in tree identification, they are used here.

Before making a key, you must know well the trees you wish to separate! Get a good tree book and by means of its keys, illustrations and descriptions learn to recognize your native trees, or at least those of the school or camp woods. You will need to learn that the conifers have small or narrow evergreen leaves (one exception in the Northeast), and that the "broadleaves" have larger, membranous leaves which fall in autumn; also that some leaves of the latter consist of one blade (simple), while others are made up of several blades (compound). Finally, leaves are staggered along the stem (alternate), or are paired (opposite) and are occasionally borne in whorls of three.

With the above information to work upon, suppose we survey the school yard and find ten different trees as represented by the accompanying leaf drawings.[1] It is assumed that you have se-

[1] These drawings were made to illustrate leaf shapes and not to represent certain species. They will, however, serve for the purposes of developing a key.

lected these leaves carefully and that they are typical. A key may be thought of as a trail which always branches in two directions. At each succeeding fork there is a signboard giving two choices, one of which you must make. Having made it, you fol-



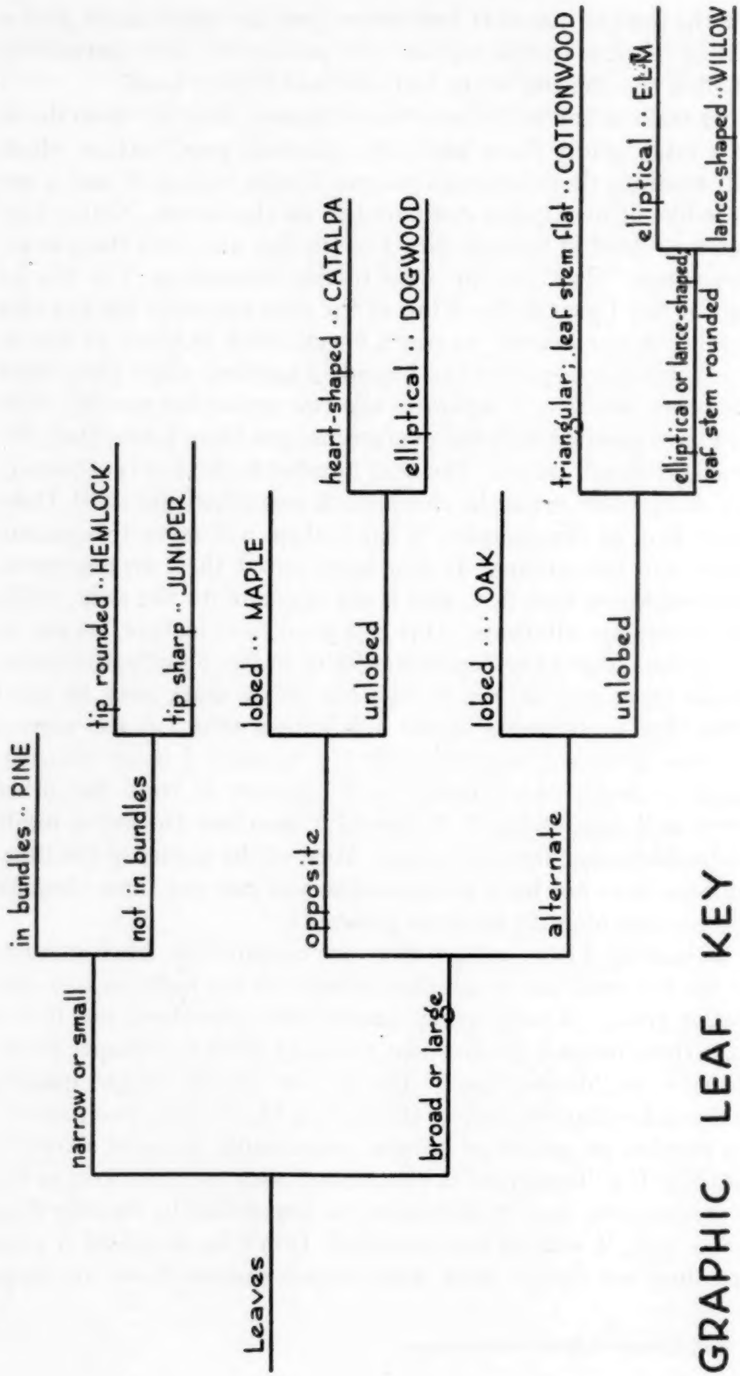
Courtesy McGraw-Hill Book Co.

low the path to the next fork where you are again faced with a pair of choices. In this fashion you proceed to your destination which is the identity of the leaf you hold in your hand.

To make a key to the ten leaves chosen, first lay them down on a table, study them and pick out some good feature which will separate them into two groups. Notice that a, b, and c are scale-like or needle-like compared to all the others. Notice how this is utilized in Section No. 1 of the key and that these evergreens now "flow" to No. 2 for further separation. The second part of No. 1 goes to No. 4 but at the time you start the key this number is not known, so put a check mark in place of No. 4. No. 2 serves to separate the 5-needled species,[2] white pine, from the other two. No. 3 separates the two remaining species. Now you have finished with the evergreens; put them aside. Only the "broad-leaves" are left. The next number in the key is obviously No. 4. Go back, erase the check mark and substitute the 4. Once again look at the samples. What feature will serve to separate them into two groups? If you have noted their arrangement, you will know that d, e, and h are opposite on the twig, while the others are alternate. This is a good field feature, so use it. No. 4 does so and the "opposites" flow to No. 5 for further separation there and at No. 6. Again a check mark may be used after "leaves alternate" until it is known that 7 is the correct number. Now you have left only f, g, i, and j. J is cut into segments (lobed), which feature will separate it from the other three as is done in No. 7. If you have seen how the key is made up to this point, the rest is easy. Most of the names of the illustrations have not been mentioned so you can run them through the key and identify them for yourself!

In making a key, be sure there are no gaps left. Each number on the left must run to another number on the right, or to a species or group. Mostly, group names have been used, but if you have three maples, for instance, you may want to separate them. Be sure to "double-space" the key as shown. Single spacing makes a key hard to follow. Of course a key is made to a particular number of species or groups, presumably those of a certain locality. If a "foreigner" is introduced, such as white ash, to the accompanying key, it will either be impossible to identify it or worse still, it will be mis-identified. Don't be surprised if your key does not always work with certain species. Some are more

[2] Only one needle is shown in the illustration.



GRAPHIC LEAF KEY

variable than others. Also, students will find loopholes or rough spots which were not evident to you when you first made the key. Be prepared to modify the key as may be necessary after it has been used by several groups of students.

Keys may be shown graphically, and may be even better than the "written" type when working with younger children.

If you will try the key idea, a new door will be opened for the further discovery of the limitless resources of the outdoor world.

Leaf Key
or
Clues to the Trees of My Schoolyard

1. Leaves narrow or needle-like, or small and scale-like; evergreen......2
1. Leaves broad; deciduous (falling in autumn).....................4

 2. Leaves needle-like, in bundles of 5.................White Pine
 2. Leaves not needle-like, not in bundles.....................3

3. Leaves about ¾" long, tip of leaf rounded................Hemlock
3. Leaves less than ½" long, tip of leaf sharp..................Juniper

 4. Leaves opposite (or in threes)..............................5
 4. Leaves alternate...7

5. Leaves lobed (cut into segments)..........................Maple
5. Leaves unlobed..6

 6. Leaves heart-shaped.....................................Catalpa
 6. Leaves elliptical..Dogwood

7. Leaves lobed (cut into segments).............................Oak
7. Leaves unlobed..8

 8. Leaves triangular, leaf stem flat...................Cottonwood
 8. Leaves elliptical or lance-shaped, leaf stem rounded.............9

9. Leaves elliptical, "lop-sided" at the base.....................Elm
9. Leaves lance-shaped, symmetrical at the base...............Willow

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HARRISON BECOMES HEAD OF AMERICAN INSTITUTE OF PHYSICS

Dr. George R. Harrison, Dean of the School of Science, Massachusetts Institute of Technology, has been elected Chairman of the American Institute of Physics, succeeding Dr. Paul E. Kloepsteg, Director of Research, Northwestern University Technological Institute.

Dr. Harrison takes over leadership of the Institute just as plans for a new journal of physics, long under development, are about to materialize. He is known throughout the world as a popularizer of physics, particularly for his book, *Atoms in Action*.

Under Dr. Klopsteg's chairmanship the Institute was recently reorganized and changed from a loose federation of the leading national societies in the field of physics to a membership organization. It is now composed of the American Physical Society, the Optical Society of America, the Acoustical Society of America, the Society of Rheology, the American Association of Physics Teachers, and about 9,000 individual members.

ADAPTING THE STUDY OF BIOLOGY TO THE ABILITY AND THE NEEDS OF SLOW-LEARNING PUPILS

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When confronted with the problem of adapting the study of biology to the ability and the needs of slow-learning pupils two questions arose. The first question was what phases of the field of biology should have the greatest direct effect upon the lives of these pupils now and in the future. The second question concerned the method of presentation.

The problem of selecting subject matter seemed to be three fold. First, the future earning power of the majority of these pupils will probably place them in the lower income groups. Therefore, it would seem that their problems might center around health, nutrition, environment, recreation, and the building of a healthy mental outlook. Second, these pupils will someday vote and perhaps become a deciding factor in issues concerning the good of the community in which they live. As many of these issues concern health, city planning, park upkeep, etc., a study of certain phases of biology should lead to some understanding of them. Third, because these pupils retain a limited amount of factual knowledge, it might be advisable to concentrate on materials which develop helpful attitudes.

As a working basis for subject matter topics were selected which seemed to best bring together the above ideas. They are, body structure and body functions, avoiding health hazards, eating for health, health and disease, conservation, environment and living, and how life is continued. (The value of recreation to be stressed whenever the opportunity presents itself). The topics were next worked into units in such a way as to bring about correlation, carry over of ideas, and some justified repetition.

Some of the facts and attitudes which it was hoped the pupils might retain and carry with them as a result of the study of these topics are as follows:

1. Health is a primary factor in earning a living and in the enjoyment of living.

* The writer wishes to acknowledge the fact that the cooperation of Mr. Wm. L. Moore, Principal of John Hay High School, and of Mr. A. E. McNelly, Director of Work for Slow-Learning Pupils, has made this work possible.

2. The body is a living machine and should be given at least as much care as the family car.
3. Much ill health may be avoided by an intelligent understanding of body structure and body needs.
4. Most accidents are the result of carelessness.
5. Man is the guardian of his own health. Doctors, nurses, hospitals, clinics, and health organizations exist to help him when he needs assistance.
6. Self-medication and self-diagnosis are dangerous.
7. A balanced relationship between plants, animals, including man, provides the best means of supporting all kinds of life.
8. All living organisms gain from other living organisms.
9. Intelligent conservation makes for better living.
10. Intelligent thinking should lead to better understanding and cooperation.
11. A direct relationship exists between mental and physical health.
12. By supporting the activities of health organizations, recreation centers, etc., one helps to safeguard the health of the city and subsequently his own health.
13. Replenishing of living things on earth is a necessary function of nature.
14. The violation of certain moral standards often leads to mental and physical maladjustments.
15. The greatest force for happiness lies within ones self.
16. Environment is a problem to all living things.
17. The effectiveness of a community depends upon the attitudes of the people who comprise it.

Having arrived at some decision concerning the subject matter next to be considered was the question of presentation. There seemed also to be three angles to this problem. First, that everything should be made pertinent to the pupil himself and afforded as much pupil participation as possible. Second, that subject material should be presented in a simple and direct manner. Third, that visualization of materials should be extensively employed for the best understanding of the subject discussed.

As textbooks and other reading matter are necessary props to learning, a first concern in presentation was to select reading material which had the direct approach and which would be simple enough for slow-learning groups to comprehend. It was no surprise to find that in the study of the simplest reading matter, slow-learning pupils need close supervision. Also, it was discovered that texts which might fulfill the needs were scarce. After much search sets of several texts[1] were selected and have proven quite satisfactory.

In actual presentation the texts are being supplemented by pamphlets from such sources as the Ohio Conservation Department, various health organizations, and manufacturing con-

[1] Titles will be given on request.

cerns. Current magazine articles and newspaper items are being used whenever available. These serve to emphasize the fact that biology reaches out into the lives of the general public. The greater part of the study of subject matter is done in the class room during the one hour periods. The pupils are guided by sets of topics, question sheets, and oral reading, followed by class discussions.

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Films serve a very important place in vivifying those subjects which cannot be studied first hand or by means of field trips. At the end of a year, the pupils have studied more than fifty films. Whenever possible, films rather than reading matter are used: for example, "The River"[3] and "The Plow That Broke The Plains"[4] form a basis for the study of conservation. The text, pamphlets and posters amplify the study. The strip film, "We Are Brothers"[5] affords a three day lesson on the problem of race. "It Can Happen Here"[6] brings home the fact that a city's wealth depends largely upon the wealth of the soil. Films are

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further used as an aid in visualizing material already studied, as a form of review, and as an impetus for future study.

In conclusion, it may be said that simple reading material concerning topics vital to the pupil, pupil participation, concrete illustrations of subjects discussed, field trips, and use of visual aids seem to be important factors to be considered in the teaching of biology to slow-learning pupils. In addition, vision, imagination, and the ability and desire to understand the background and the handicaps of the pupils, are important qualities for the teacher to possess. Also as there seems to be as wide a range in pupil personality and pupil ability within these groups as is found in the groups of average and above average pupils, it is a great help to keep the size of the classes small. Small classes afford time for individual attention, a point which cannot be over-stressed because these pupils need encouragement and need to be held to a goal commensurate to their ability. By means of individual help, most of them can be given the satisfaction of a job well done and what is more important, they can be helped along the way to becoming self-supporting, self-respecting, and loyal citizens.

ARITHMETIC JACK BUILT

This is ARITHMETIC Jack built
This is BASE TEN that lay in ARITHMETIC Jack built
This is DECIMAL FRACTION of things that spoiled BASE TEN
This is METRIC SYSTEM that adopted DECIMAL FRACTION of things
This is OCTIC HALF with auto horn that doomed METRIC SYSTEM
This is BASE AIT without a third that advertised OCTIC HALF
This is TEACHER all forlorn she taught BASE AIT without a third
This is MEASURING EFFICIENCY neglected and scorned he loved TEACHER all forlorn
This is PSYCHOLOGY all doctored and profed who married MEASURING EFFICIENCY
This is COMPETITION having insistent voice that waked PSYCHOLOGY
This is INDUSTRY only real builder of jobs who raised COMPETITION having insistent voice that waked PSYCHOLOGY all doctored and profed who married MEASURING EFFICIENCY neglected and scorned he loved TEACHER all forlorn she taught BASE AIT without a third that advertised OCTIC HALF with auto horn that doomed METRIC SYSTEM that adopted DECIMAL FRACTION of things that spoiled BASE TEN that lay in ARITHMETIC Jack built.

Contributed by a reader of
SCHOOL SCIENCE AND MATHEMATICS

ELEMENTARY SCIENCE AND SOCIETY

A FIFTH GRADE UNIT IN ELECTRICITY

ILLA PODENDORF

Laboratory School, University of Chicago

If we were to ask ourselves to what goal we as science teachers are striving, we would probably say something like this: enriched living or better adjustment in our environments. If we were to break this goal down into objectives, we probably would list them somewhat as did a group of science teachers in my school. The list is as follows:

1. To build up a fund of knowledge about materials and phenomena in one's environment.
2. To widen the range of interest and find ways of using leisure time.
3. To help develop work habits and study skills.
4. To establish good health habits.
5. To think critically and creatively.
6. To develop a scientific attitude.
7. To develop an appreciation of the part science plays in the world today and of the vast amount of effort that has gone into building up the body of science information.
8. To understand relationships between science and society.

When we examine these objectives closely, we recognize that some of them are the responsibility of the entire school system while others are almost entirely dependent upon the science department for their development. These of course have a special challenge to us, some of them more in certain environmental circumstances than in others, and some of them more at certain grade levels than at others. To know about materials and phenomena in an environment and to be able to think critically about them tends to make people more secure. To make children more secure in their environments has an unusually strong challenge to us today.

Probably there never was a time when so great a number of nations were less secure in their relationship to the rest of the world. Perhaps there never was a time when the adult populations making up the nations were less secure in their own immediate societies. Doubtless this insecurity is reflected in the lives of children. The surrounding conditions, tensions, and all daily experiences are closest and most real to them. It follows then that there probably never was a time when it was more important to help children to feel secure in their environment. Just as the use and control of atomic energy is an unknown to adults, many things are unknowns to children. They have not

only the unknowns they hear adults talking about, but they have unknowns of their own too. For example, some children think about and worry about whether day will ever fail to come, what causes rain, what causes lightning, what causes day and night, and why lights go on when you push a button.

For both adults and children insecurity is often due to lack of knowledge or the ability to think independently. Knowledge and straight thinking give security because they give power to function. The power to function gives faith in ourselves and the future.

This brings us to the selection of a body of subject matter which will bring about some of the desired outcomes. No one unit can be used to bring about improvement in all the desired directions.

A unit in electricity takes care of several of the glaring unknowns in a child's life. It answers such questions as, "What causes lightning? Why can lights be made to go off and on again? Why do irons heat?" Such a unit also offers opportunities for developing habits of observation, problem solving, and the manipulation of equipment, and leads into worth while leisure time activities.

Here is one way to develop such a unit with a 5th grade class. Introduce the unit with discussion. Through this discussion such questions as the following are almost sure to be raised:

Why do lights go on when you push a button?
Where does electricity come from?
Why does an electric iron get hot?
How are light bulbs made?
Why do lights some times fail to come on?
What are fuses?
What do batteries have in them?
What are good conductors of electricity?
What makes electricity dangerous?
What makes bells and buzzers work?
Why do we see sparks when we stroke a cat's fur in the dark?
What causes lightning?

With the above questions in mind the children are ready to proceed to find the answers. The answers may be found by reading, watching the teacher do experiments, by doing experiments themselves, and by thinking about and discussing what they have seen or read.

For reading material there are several good elementary science books such as *Discovering Our World*, Book III, by Beauchamp, Melrose, and Blough (Scott, Foresman, Co.) which are

useful. The references here are made to the unitext *Electricity* by Bertha Parker (Row, Peterson Co.) since that is the book used in developing this unit.

For experiments, the selection is dependent upon the amount of equipment and the teacher. The more experiments the children can do for themselves the better training it is for them. The following is a list of equipment which we had in the class room available to the children, and a list of experiments which children can do individually.

Materials for a Class of 15-18 People

12 dry cells
18 small light bulbs and sockets
6 buzzers
4 bells
3 motors
4 telegraph sets
2 telephone sets (transmitter and receivers)
1 large spool of copper wire
12 screw drivers
12 single-throw switches
12 double-throw switches
6 push buttons
small amount of mercury
1 brass rod
1 iron rod
1 sheet of zinc
2 electromagnets (one large—one small)
1 question board
1 box to serve as a house
1 small generator

Experiments

1. Connect a cell, a light, and a single-throw switch.
2. Connect two cells, a light, and a switch.
3. Connect a cell, a light, and a push button.
4. Connect two cells, a light, and a push button.
5. Use one dry cell, a small lamp bulb, and one piece of insulated wire and make the bulb light.
6. Make a bell ring in three different ways.
7. Connect a buzzer, one dry cell, and a push button.
8. Connect a buzzer, two dry cells, and a push button.
9. Connect a motor, two dry cells, and a switch.
10. Connect a switch, a dry cell, and an electromagnet.
11. Connect a switch, two dry cells, and a large electromagnet.
12. Show in any way that you choose that iron, brass and zinc are good conductors of electricity.
13. Determine for youself whether mercury is a good conductor of electricity.
14. Determine for youself whether rubber, cotton, and wood are good conductors of electricity.
15. Make a list of things which are good conductors and a list of things

which are not good conductors. Be sure you have at least ten things in each list.

16. Connect a telegraph set and two dry cells. Prepare to spell your first name in Morse code. See page 31 in *Electricity* for help.
17. Connect a telephone transmitter, telephone receiver, and two dry cells. See page 33 in *Electricity* for help.
18. Connect three lights in series using two dry cells.
19. Connect two dry cells and three light bulbs in parallel.
20. Use the hand generator and make the bulb light.
21. Set up the circuit shown in the left hand drawing on page 34.
22. Set up the circuit shown in the left hand drawing on page 35.
23. Use two cells, a motor, an electromagnet and a double-throw switch and connect them so that either the motor or the electromagnet can be made to work.
24. Connect a buzzer, a cell, and two push buttons in such a way that the buzzer will ring when either button is pushed.
25. Connect two cells, two telephone receivers, and two transmitters in such a way that two people may talk from one room to the other.
26. Connect two telegraph sets and two cells so that messages may be sent from one person to another.
27. Wire an electric question board.
28. Wire the house so that a bell will ring from either the front or back door.
29. Make plans for and wire a complicated set up of your own.

All teacher demonstrations should be done with a problem in the minds of the children. The children should be given a good opportunity to do close observation and good thinking. For example, show the class two sets of Christmas tree lights, one set connected in series and the other in parallel. Ask the children to figure out a reason why one stays lit and the other goes out if one bulb is taken out of each. After they have arrived at a decision, they may, with the teacher's help, wire two circuits to show how they think the lights must have been wired. Then they may read to check their thinking. Some other experiments which can be done by demonstration are setting up wet cells, taking apart a dry cell to identify parts, experiments with static electricity, etc.

As the reading, experimentation, etc. progresses, study sheets are done on the reading material. Study sheets help the child to put his ideas into words. Some sample questions used on the study sheets were as follows:

Is today a good day for for experiments with frictional electricity? What makes you think so?

What is the difference between a cell and a battery?

Would it be a help if all materials were good conductors of electricity? Why or why not?

Toward the end of the unit a discussion period should be spent answering each of the questions raised at the introduction of

the unit. At this point the important concepts of electricity can be stressed. One day can well be spent playing the following game. Children prepare for the game by writing yes and no questions about electricity. The children are seated in a semicircle and each in turn answers a question. If he misses the question, he moves to the foot of the line and those between him and foot move up. When there are four children who have missed a question, they stand up and attempt to buy seats from those who haven't missed by asking questions. Another testing device is what might be called trouble shooting. Have several circuits set up which will not work. The children look for the trouble and correct it.

The success of such a unit depends upon the planning which goes into it. Here are some suggestions for planning for such a unit which may be helpful.

Take the children into the overall planning for the unit.

Identify with them the equipment and discuss with them the plan for using it.

Make sure the equipment necessary for the experiments which they are to do is available to them.

Type directions for doing the experiments on activity cards. About six can be put on each card and the cards numbered 1-2-3 in order of difficulty. The children then do their experiments at their own rate of speed in the order given. In this way the use of the equipment is staggered and the class can operate with a lesser amount of equipment. There should be enough cards so that each two children may have one. The directions should be complete enough so that the child knows what he is to accomplish; but leave enough to the child's thinking so that he has an opportunity to show his own initiative in planning.

For keeping a record each child may be given a card numbered around the border to correspond with the numbers of the experiments and study sheets. As each one is completed and approved by the teacher, the number is punched out on the card. This card can be kept by the student.

Any two days' work may proceed something like this: At the door each child is given a piece of paper and asked to write the word electricity spelled correctly on it for a ticket to get into the room. When the class is inside and seated, a discussion is started by asking the children whether they think the elecricity used to light the lights in the room comes from dry cells. After the discussion has led to an idea about where the electricity comes from, they are asked to read *Electricity*, pp. 18–19, to check their information. Then they are shown a hand generator which each child is allowed to operate. After that, each child identifies the two important parts of the generator to the teacher and then proceeds to his individual experiments for the remainder of the period. The next day as a pass word each member of the class is asked at the door of the class room to give the name of the piece of machinery which produces electricity for the city. As the child gives the pass word, he receives a study sheet with questions about the generator. When the sheet is finished correctly, each child proceeds to his own program of experiments.

Such a unit is very popular with children. This is not the only way to present such material. It is one way which has been found successful. The plan is most successful with a group of 20 people. It has been followed successfully with a larger group by staggering the activities sufficiently. Other units can be developed in much the same way, while some do not lend themselves to this type of organization. Other types of organization and content material help to broaden children's experiences and give support to other objectives. It is important only that the learning is functional and that it relates directly to life situations. The task of the teacher then is selecting materials and following methods from which functional learning will result. It is important that the children recognize and identify the learning outcomes and that the outcomes contribute toward greater security in their lives.

HOW TO IMPROVE OUR TESTS

B. Clifford Hendricks
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A G.I., his wife and three children had to buy a property in order to have residence while he completed his professional training for specialization. He and family are now concerned with "How improve our property?"

Obviously the answer to the question is dependent upon another, "To what end is this improvement?" Is the improvement contemplating a resale? Maybe it proposes to make the property the show-place of the community; an effort to out-do the Jones's? Or perhaps it is but the expression of a wish to join with Edgar Guest when he says "It takes a heap of livin' to make a house a home" but speeding the wish and the "heap of livin'" by use of material aids.

Once the purpose of the improvement has been identified immediately a blue-print of its achievement must be set up so that the modifications needed may be high-lighted. These differences between the "as is" and the "place to be" are the points of departure for the improvement program.

Improvement of tests also requires a census taking. First the total picture needs consideration.[1] Perhaps the picture needs

[1] Horton, Clark W., "Achievement Tests in Relation to Teaching Objectives in General College Botany," Publication No. 120, Botanical Society of America, page 10 (1939).

enlargement. In the hurry of our times, with many other than subjectmatter demands competing for attention, we teachers may be neglecting values in our school courses that are much more significant in the lives of our students than the courses' information content. Inspection of tests used by college teachers leaves that impression.[2] Forty or fewer years ago teachers gave lip service to what were called concomitant values of science and mathematics. They found, however, that too many times school courses seemed to make little change in the students in line with the "concomitant values." The psychologists pointed out that teaching directed toward such aims should share the aims with the pupils; i.e. the student should be made conscious of that purpose and that provision should be made for practice with that aim in view. Is it not in order to suggest that after the practice, use should be made of tests which are valid as indices of the achievement of such values? If so, the further proposal that the students be motivated to *want* to take these tests rather than that they be induced to become appositive, by suggestion, and assume the attitude that "the teacher made us take the exams."

Item number one, then, on this program of test improvement, is: Plan for next school year's work by a critical though afirmative consideration of an enlarged expectancy from that which the individual courses may achieve for the students and make provision to help the students become conscious of that enlargement through the service of proper tests.

Another item, on the score card of our test improvement agenda, may be posed by the question: "Do the forms of tests I am using get the desired census of understandings, skills and traits better than others that are available?" There are still many teachers who insist on preparing their own tests when they should know there are certainly some tests on the market that are better than their "home made" tests.[3] Most teachers do not write their own text books or laboratory manuals.Their reason for not so doing is that they can buy better ones than they can write.

Even if it is necessary to assemble the test locally the form of item used may be modified in an effort to improve its goodness."[4]

[2] Hendricks, B. Clifford and Handorf, B. H., "Examination Practice in General College Chemistry," *J. Chem. Educ.*, 15, 176–179 (April, 1938).

[3] Hendricks, B. Clifford and Smith, O. M., "Service Tests for Chemistry," SCHOOL SCIENCE AND MATHEMATICS, *35*, 488–491 (May, 1935).

[4] Kendricks, B. Clifford and Handorf, B. H., "New Examinations from Old," *J. Chem. Educ.*, *16*, 329-332 (July, 1939).

Experienced teachers know that essay items may be greatly improved by rephrasing, especially after student answers have revealed a meaning the examiner had not expected as he formulated the requirement. Maybe the item should be one of the multiple choice type, or it might use the master list device or the completion form or a combination true-false and completion or other combinations. The teacher who is genuinely anxious to improve his tests will experiment with different test item forms. He will, of course, validate such experimental items by use of pupil answers as previously described,[5] in order to justify or modify for later use.

An experienced teacher is generally alert and avoids certain pitfalls into which the beginner in examination building may stumble. For essay examinations,[6] two may be mentioned. Often a single word in a test item defeats the purpose of the question. A question in one test read: "State Boyles' law." The student did not answer it correctly because he didn't remember which law was labelled "Boyles' law." When asked: "State the pressure-volume law" he answered correctly. The first statement of the question was really two questions in one: "What is the statement of the pressure-volume law and by what historic name is it sometimes labelled?" In another examination the students were asked to "Define an acid." When the answers were read it became evident that many pupils did not know the definition of "Define." Perhaps a definition of define should be stated in the question before requiring its application in the question. For surely, in a chemistry examination, this item is concerned principally with acids and not so much with the word define. There are many other words, much used in essay examinations, which need our critical attention. The following are a few of those occurring most frequently: contrast, discuss, describe, illustrate, interpret, justify, compare, criticize, explain, outline, review, summarize, etc.

In science and mathematics problems are favorite test items[7] but the teaching novice, too often, is all too innocent of the complexities a problem may present, especially to the beginning student. To illustrate: A problem in one examination read "Hydrogen has a density of 0.09 grams per liter at standard

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[5] Hendricks, B. Clifford and Smith, Otto M., "Better New Examinations from Old," *J. Chem. Educ.*, *17*, 583–586 (Dec., 1940).

[6] Frutchey, Fred P. and Hendricks, B. Clifford, "The Essay Examination in Chemistry," *J. Chem. Educ.*, *16*, 491–493 (Oct., 1939).

[7] Hendricks, B. Clifford, "New Type Tests Meet a Need," *J. Chem. Educ.*, *4*, 1420 (Nov., 1927).

conditions. Phosphoric acid is 3.1% hydrogen. Enough sodium (amalgam) was put into phosphoric acid to produce twenty-five liters of hydrogen gas at standard conditions. What weight of acid was used?" An analysis of this problem's requirements uncovers six or eight elements of difficulty for the beginning student. Listed, they are: the reaction involved, knowledge of chemical composition, working concepts of, density, standard conditions, per cent, decimals, multiplication, division and subtraction. Such a test item is often scored entirely on the basis of the correct numerical result. Thus a zero may be due to lack of understanding of any one or more of the six or more elements of difficulty. The score of this question, to be useful to teacher or pupil, should attempt, at least, to localize the successes and difficulties of the student. By setting up four or five specific, but not too inter-dependent, sub-requirements, as suggested below, such an analysis may be approximated. ***Suggested problem requirement:*** Directions: Complete 1 and classify 2, 3, 4 and 5 by placing *X* before them if they are wrong or *C* if they are correct. Correct all those items marked *X* by putting the correction for the italicized phrase upon the blank following the statement.

____ 1. The reaction is: Phosphoric acid + sodium = ______ + ______
____ 2. One liter of hydrogen (S.C.) weighs *0.09* grams. 2. ______
____ 3. 3.1% is *0.31* of the acid. 3. ______
____ 4. 25 liters (S.C.) of hydrogen weights *25×.09* grams. 4. ______
____ 5. *0.031%* of the acid is the weight of the hydrogen. 5. ______
____ 6. The weight of the acid needed is *76.2* grams. 6. ______

The beginner in composing "new type" items, using true-false, multiple choice, completion and master list forms, is prone to over-weight the test with demands for information or memory items.[8] Especially may this result in composing true-false tests. This doesn't have to be so, however. If the item interprets, illustrates or applies a principle, law or theory it will demand both thinking and memory. To be sure, if the item is a repetition of a statement made in class or in the textbook, memory may serve alone but that can be prevented if such items call for situations that are new to all students taking the test. Confronted by the true-false item: "The pressure-volume gas law is illustrated when you blow soap bubbles" the unthinking student will mark it "true" and get a discount. He remembers the law but not with precision. If this had been discussed in

[8] Engelhart, Max D., "How Teachers Can Improve Their Tests," *Chicago Public Schools Journal*, Sept.–Dec., 1943.

class he very probably would have remembered its error.

The use of the multiple choice form is generally advised by test makers because it is reputed to minimize successful guessing that is possible in the true-false tests. This assumption, that there is less chance to guess successfully in multiple choice, is definitely open to question if the decoy items are too obviously incorrect. In choosing the *best* for the following item: "Chlorine sterilizes water because chlorine is: 1, Soluble; 2, A germicide; 3, Greenish-yellow; 4, Denser than air" suggestions 3 and 4 are very poor decoys. If 3 were changed to "Insoluble" and 4 to "A reactant with water" the choice between 1 and 2 would have been better competition.

A fruitful method of making certain that more than memory is required in answering test items is to formulate items designed to evoke "discriminative thinking."[8] Such an item for physics might be:

Classify each of the statements 1–5 by placing upon the blank following:
A if the item is true for electricity.
B if the item is true for magnetism.
C if the item is true for both.

1. Its opposites attract. 1. ______
2. It may move through copper wire. 2. ______
3. It may be produced by chemical change. 3. ______
4. Its intensity may be influenced by materials in its field. 4. ______
5. Its smallest units do not have mass. 5. ______

In an essay test the requirement would probably have read: "Compare electricity and magnetism." The pupil's answer would be largely dependent upon his understanding of the word "compare." This would probably vary from student to student and is, to a considerable degree, extraneous to his knowledge of magnetism and electricity. It should be noted that memory is required in answering the first form given in this paragraph but memory of magnetism and electricity has to be "synthesized" before making the classification.

Doctor Clark W. Horton has summarized, most effectively, the bases of continued improvement in the evaluation of student achievement, not only for botany but for other sciences and mathematics as well. That which follows is quoted from his publication.[1] "Improvement in the evaluation of student achievement appears to involve the following:

1. An increase in the practice of stating objectives realistically, and in the practice of so defining them in terms of student behavior that they become useful as guides both in

planning teaching and in the collection of evidence of achievement;

2. An increased dissatisfaction with testing primarily for the purpose of assigning grades to students;

3. An increased use of tests for discovering the deficiencies and difficulties of students, and an increased use of this information in advising and guiding students, in providing remedial instruction, and in adjusting the content and teaching procedures of the course to the needs of the students;

4. A decrease in the practice of judging achievement primarily on the amount of information a student has acquired by the end of the course;

5. An increased effort to evaluate the attainment of goals of instruction other than the acquisition of information—particularly aspects of thinking involved in the use of the scientific method and in scientific attitudes;

6. The replacement of many judgments based upon vague impressions or on unreliable samples of behavior, by judgments based upon valid, objective, reliable data—in short, the application of fundamental safeguards of the scientific method to the collection of evidence about persons;

7. An increased willingness on the part of teachers to investigate, through the collection of adequate data, the effectiveness their teaching has in actually bringing about the changes in students that they cite to justify . . . (the effectiveness of their teaching);

8. A willingness on the part of teachers to give more time to the construction of tests, to their use in the class room, and to the interpretation of the evidence they yield;

9. Increased cooperation among . . . (teachers) in the improvement of testing practices, the exchange of tests, of the ideas about tests and of criticisms."

AERONAUTICAL RESEARCH SCIENTIST

Dear Sir:

Enclosed is an announcement of an examination for filling Aeronautical Research Scientist positions with the National Advisory Committee for Aeronautics. This examination offers an opportunity for research-minded scientists with training in engineering, physics, chemistry, mathematics, or related physical sciences to compete for probational appointment to positions paying from $3,397 to $9,975 a year. Most of the positions to be filled are in the NACA field laboratories which are located in Hampton, Virginia; Moffett Field, California; and Cleveland, Ohio.

See the Ed if interested. Good by, science teachers.

A MATH CIRCUS

Paul W. Lehmann
Dublin School, Dublin, New Hampshire

A math circus, as held at the Dublin School, Dublin, New Hampshire, on January 29, 1947, could be defined as a morning of instructive mathematical recreation, whose purpose is not only to increase interest in mathematics *per se*, but also to develop students' awareness of things around them, especially of the unusual aspects of supposedly commonplace objects. The circus was arranged and conducted by Mr. Norman B. Wight, head of the mathematics department.

The circus was conveniently held in the assembly room, all students (56 students, grades 6–12) participating simultaneously and lasted from 8 to 12 o'clock, with a half-hour recess about 10:30. Events proved varied and intrinsically interesting enough to hold the attention well throughout the whole of this period.

Though considerable time had to go into the preparations for the circus. the show itself was put on by one teacher, assisted by two mathematically competent seniors. Apparatus was extremely simple: a blackboard plus an aggregation of such small, easily obtained objects as wires, thumb-tacks, paper, beans, needles and the like.

The master of ceremonies opened with a brief introductory talk designed to acquaint the audience with the purpose and general nature of the performance. This particular circus was organized around a central controlling theme, namely the *circle*. Everyone was made aware, at the outset, of how ubiquitous in all human environment is the circle and its segments, along with curves in general. From the celestial bodies all the way down to thimbles and water-drops, we seem to be living in an amazing curvilinear universe.

Actual demonstrations began with the attempt by the instructor to draw a *line* on the blackboard. Everyone but math sharks were surprised to find that this apparently simple task was impossible of accomplishment. Only by superimposing differently colored papers over each other was it possible to present an edge that could satisfy the mathematical conception of a line, i.e. an entity having length without width or depth. This experiment, along with others like it, furnished a nice demonstration of precise thinking. It become obvious that the exact application of a simple definition could result in some rather

puzzling facts and dilemmas. One amusing figure was the hypothetically flat man living in two dimensions, unable to swat the mosquito torturing the end of his nose.

Animated discussions were elicited by the problem of what happens to the hole when you eat the doughnut. People began wondering before long what a hole was, anyway—and even if such a thing existed. The hole proved to be a cantankerous thing when closely studied, full of unexpected and miraculous tricks.

The next event concerned the relation of diameter to circumference, in a word, π. π was examined in both abstract and concrete terms. This study provided a splendid illustration of contrast between mathematical exactness and practical convenience in computation. The event was topped by an ingenious card-and-needle game in which π was derived by that prodigious wizard known as the law of probability.

Everyone was given a break from sitting still by the invitation to walk about and inspect the wall exhibits. One series of these consisted of "seen and unseen" problems of estimate, grouped in corresponding pairs. The saunterer, for example, would find a book. The "seen" problem was to estimate how many such books could be shelved in the also-visible library space. The "unseen" counterpart was to estimate how many stars are visible to a good pair of naked eyes on a clear moonless night. Answers to all this group of problems were, of course, supplied later by the instructor, when all were again seated and permitted to express their estimates orally. The pay-off here was in the uncanny accuracy of some reckonings, and the grotesque errors of others.

On the wall were also a group of apparently paradoxical figures, such as "a hole through a hole in a hole," a "closed surface with no inside and no outside," etc. Interesting in this set, too, were the circular, hexagonal, and square orifices successively assumed by the contracting pupil of the King Penguin's eye! The penguin was not, however, the only exemplar of "natural geometry." Covering one panel was a great array of colored photographs depicting objects representing a range all the way from the remote reaches of astronomy to the minute world of the microscope. Here were curves galore—curves in nature, in architecture, in engineering, in kitchen utensils, in human anatomy. The curve appears to be not only a favorite natural assertion of the Divine Architect, but also the instinctive gesture

of functional design in its most fundamental character and widest scope of application.

A final dynamic demonstration consisted of a spotted wooden wheel rolling along an inclined wire in such a manner as to allow the observer to visualize the trajectory of a given point on a wheel. What points on a wheel really do when rolling is an astonishing revelation to all but the initiated.

The instructor apeared momentarily in the role of magician when he held up before his audience a card on which were the numbers 1, 2, 3, 4. Each boy was then asked to select one of these four numbers and write it down. Then the performer asked the spectator, at random, which number he had selected. It turned out to be 3. The magician then showed the reverse side of his own card, on which was written, *before the boy had made his selection*, "you will pick No. 3." The group was properly mystified, and more so yet when investigation showed that a good majority had shown the same unconscious preference for No. 3. Did the curves in figure 3 account for the phenomenon? Was there some obscure psychological law operating to produce this freak numerical election? Our performer admitted, with a grin, that he just didn't know—it simply worked that way every time he tried it.

The circus ended in a sort of climax with the game of Beano (alias Bingo) played with various mathematical entities on the squares. These figures were recognizable by direct and indirect definitions which were read aloud by an assistant. Any five coverings in a row scored a win, and first and second prizes were awarded the first two winners.

MATH CIRCUS PROGRAM

8:00 An illustrated talk by the instructor using the theme of the day and showing relations of our world to a world of two dimensions. The talk carries to the next event by a discussion of π which we derive by measurement first.

8:30 Game of π. It is a demonstration of the derivation of π by probability.

9:00 How well do you see and guess? Estimating distance, area, volume quantity, angles of familiar and not too familiar objects. It was begun by estimating height of village flagpole as a group, and then having boys circulate to printed cards on the wall.

10:00 Demonstration. Consisting of an inclined wire down which a wheel was rolled. Bright red spots were used to show the paths taken by various points on the wheel. This is supplemented by various aspects of curves in everyday life.

10:30 Play: A Typical Day in Math Class. This was a very simple but very individual caricature of boys in school.

11:00 Recess, with refreshments. At which time the boys circulated to look at the pictures, posters and diagrams designed to stimulate ideas. When recess was over we commented briefly on the observations by various boys.

11:30 to 12:00 Mathematical Beano. This was just what the name suggests using simple concepts on cards. Each boy had a card. Prizes were awarded the winners of the first two games.

APPLIED MATHEMATICS IN GENERAL CHEMISTRY

SISTER M. IGNATIA

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In the introductory college course in chemistry one of the main difficulties and causes of failure is the mathematics involved. Too often a student because of a fear or distaste for all things mathematical will avoid chemistry entirely, or if he does take the course, will be handicapped unless he receives suitable instruction and guidance. Even though no student be admitted to General Chemistry unless he has had one year of algebra and one year of geometry in high school, a great responsibility in this connection rests on the chemistry instructor. This responsibility cannot be fulfilled by merely requiring the students to purchase a separate problem book, or to solve a stated number of problems on the final examination.

The mathematics used in General Chemistry can be summarized under the headings:

1. Addition, subtraction, multiplication, and division
2. Proportion
3. Other equations
4. Powers and roots
5. Scientific notation

These are absolutely essential to the student of chemistry, but frequently he remembers little of algebra beyond "transposing," "cross-multiplying," and "cancelling," which to him are mechanical tricks without a logical foundation. The chemistry instructor must, therefore, teach or reteach all the mathematics used in his course, beyond the four most fundamental processes of arithmetic. The reteaching of basic algebra should preferably be done not at the beginning of the course in General Chemistry, but as the need arises, and should be part of a regular program to develop in the student certain specific abilities.

Basic among these abilities is the power to read and analyze

a problem. To read a problem the student must know the meaning of the words used in it; this, in turn, demands accurate understanding of definitions. To analyze a problem the student must not only ask himself the questions:

1. What am I asked to find?
2. What facts are given in the problem?

but he should also organize the answers to these questions in a manner which will aid his thinking without taking too much time. It is more efficient to let the organization depend on the nature of the individual problem than to teach one pattern for all.

A problem based on Raoult's law, for instance, can be analyzed under the headings:

Wt. solute	*Wt. solvent*	ΔT_f

where ΔT_f stands for the lowering of the freezing point. This system has the advantage not only of organizing the information given in the problem, but also of providing a logical framework for its solution. A problem based on the gas laws can usually be analyzed under these headings:

	Volume	*Temperature*	*Pressure*
Room conditions:			
Standard conditions:			

Ordinarily students will adopt such methods of analysis if they see the instructor using them in class. They are really grateful for aids to orderly thinking.

Once the problem has been analyzed the student must be able to recall the required combination of fact, definition, principle, and law, and to translate it into mathematical language. Consider this problem:

Calculate the molecular weight of a substance 10 g. of which in 100 g. of water lowers the freezing point of water 0.31°C.[1]

Wt. solute	*Wt. solvent*	ΔT_f
10 g.	100 g.	0.31°C.

If the student recognizes that the problem is based on Raoult's law, the definition of a one molal solution, and the fact that the molal depression of the freezing point of water is 1.86° C., he puts down under the same headings:

100 g.	1000 g.	0.31°C.
x g. = 1 mole	1000 g.	1.86°C.

[1] Timm, *General Chemistry*, p. 214.

Now he is ready to set up a proportion to solve for the required molecular weight.

Solving for the unknown specified by the problem, whether it be done by proportion, formula, or other type of equation, should always be done intelligently rather than mechanically. The word intelligently implies that the student knows the reason for each step of the process, not in terms of trick phrases as "cross-multiplying" or "cancelling," but in terms of mathematical principles. If he starts with an equation, it will remain an equation if, and only if, he treats both sides alike. Consequently, he must add the same quantity to both sides of the equation, multiply or divide both sides by the same number, raise each side to the same power, or extract the same root of both sides. He should be drilled until he actually thinks of the proper principle as he takes each step in the solution of an equation.

The fractional form of the proportion is superior to the dot form, because the former can be handled by principle as an equation, while the latter depends on a mechanical rule for its solution. The dot form appears, however, in some chemistry textbooks and on many blackboards. In 1928 the Sectional Committee on Scientific and Engineering Symbols and Abbreviations, a committee consisting of representatives of thirty-four national societies, associations, and government departments, and jointly sponsored by the A.A.A.S., A.S.C.E., A.I.E.E., S.P.E.E., and the A.S.M.E., recommended that the dot form of the proportion be dropped.[2]

The most convenient position for the unknown quantity is the upper left hand corner of the proportion, and the student should be encouraged to place it there. He should also realize that eight correct proportions can be written with the same set of data and that of these eight, two have the x in the most convenient position. Reading the fractional form as he would the dot form of the proportion often enables him to tell whether or not he has set it up correctly. Until he develops this feeling for correctness, he should apply a check before attempting to solve the equation.

Consider the proportion used in the solution of the problem quoted above:

$$\frac{x\text{ g.}}{100\text{ g.}}=\frac{1.86^\circ\text{ C.}}{0.31^\circ\text{ C.}}.$$

[2] "American Standard Mathematical Symbols," *American Mathematical Monthly*, 35 (June–July, 1928), 300–304.

It can be read as x is to 100 as 1.86° is to 0.31° or x bears the same relation to 100 that 1.86° bears to 0.31°. This is a statement of an equality between two ratios or relationships, hence the two numbers on the top must have something in common, the two on the bottom something in common, the two on the left and the two on the right something in common. The student can think:

x g. causes a ΔT_f of 1.86°C.
100 g. causes a ΔT_f of 0.31°C.
x g. and 100 g. are both weights of solute
1.86°C. and 0.31°C. are both lowerings of the freezing point.

In using this check at the blackboard the instructor can stress these relationships by curved lines:

$$\left(\frac{x\text{ g.}}{100\text{ g.}}=\frac{1.86^\circ\text{ C.}}{0.31^\circ\text{ C.}}\cdot\right)$$

To solve a proportion the student should not cross-multiply, but should multiply both sides of the equation by the same number for the purpose of getting the unknown alone on one side of the equation. This saves one step in the solution and is far more logical than cross-multiplying.

The indirect proportion is so difficult to set up in its fractional form that it is wise to handle simple inverse variation as an equality between two products. The students can be convinced of the validity of this form by simple examples illustrating Boyle's law.

T	P	V	PV
20°C.	1 atm.	100 ml.	100
20°C.	2 atm.	50 ml.	100
20°C.	½ atm.	200 ml.	100
20°C.	4 atm.	v ml.	

Since PV is a constant for a given weight of a particular gas as long as the temperature remains constant, PV under one set of conditions is equal to PV under a second set of conditions.

$$4\times v=1\times 100$$

$$v=25$$

Mechanical substitution in a memorized formula should be avoided as much as possible. The student does more reasoning and learns more chemistry if he applies a definition or a law (which he must be able to state in words anyway) to the data

of a problem, than if he merely uses a formula. Take a simple gas law problem:

A sample of gas occupies a volume of 10 liters at a temperature of 91°C. and a pressure of 380 mm. Calculate its volume under standard conditions.[3]

	V	*T*	*P*
Room conditions:	10 l.	91°C. = 364°A.	380 mm.
Standard conditions:	v l.	0°C. = 273°A.	760 mm.

The student could substitute these values in the general gas equation or he could set up his own equation by applying the gas laws. To do the latter he thinks that the new volume is equal to the original volume multiplied by two correcting ratios, one of absolute temperatures, the other of pressures.

$$v = 10\ \text{l.} \times \underline{\qquad\qquad} \times \underline{\qquad\qquad}.$$

If we consider for the moment that the change in pressure follows the change in temperature, the effect of the latter upon the volume can be predicted by means of Charles' law which states that when the pressure is constant, the volume of a gas and its absolute temperature vary directly. If the temperature decreases, it will cause a decrease in volume. When a number like 6 is multiplied by a fraction whose numerator is smaller than the denominator, say $\frac{2}{3}$, the product is less than the original number. If the gas law predicts that the change in temperature causes a decrease in volume, the smaller of the two temperatures must go in the numerator of the correcting fraction.

$$v = 10\ \text{l.} \times \frac{273^\circ\ \text{A.}}{364^\circ\ \text{A.}} \times \frac{380\ \text{mm.}}{760\ \text{mm.}}\,.$$

At first this method of solution will take longer than substitution in the general gas equation, but the student understands the gas laws more thoroughly every time he thinks through such a problem, and he is far more apt to remember this method than the general formula.

The computation involved in solving this equation is best handled by a slide rule or by logarithms. The instructor of General Chemistry can seldom afford class time to teach these time-savers, but many of the students learn how to use them in other courses or pick them up on the side. If the student must resort to ordinary multiplication and division, he should beware of cancelling, and should think of it as dividing both numerator

[3] Timm, *General Chemistry*, p. 108.

and denominator of a fraction by the same number. If he is taught something of significant figures, he will avoid the waste of time caused by carrying out a division to more than the required number of places.

Many of the devices for the simplication of chemical arithmetic are more complicated than are the problems themselves. In general, it is better to avoid mechanical tricks as far as possible and to stress the logical application of chemical and mathematical principles. The student should not try to fit all problems into a certain number of fixed categories or types. He should analyze each problem separately and apply the proper fact, definition, principle, or law. Above all, he should not lean too heavily upon the textbook or the problem book. He should master the material they present, but he should not seek a model for each problem he is asked to solve. If he develops in himself the ability to read, to analyze, and to solve by application of principles, the problems he meets, he will do well in General Chemistry and will be equipped for more advanced courses.

Two more powers essential to problem solving are the correct handling of units and the checking of the final answer. When a problem is analyzed as shown above, the unit in which the final answer is expressed will frequently be self-evident and recorded. In that case it is not necessary for the students to carry the units in the equation. In ambiguous cases, however, the student could put the units in the equation and multiply and divide by these units as he would by ordinary numbers.

To check an answer a student can usually go back to the original problem and by mental or written arithmetic see whether or not his answer is logical and of the right order of magnitude.

Powers and roots, and the scientific notation required by the study of equilibrium, have to be taught and drilled by the chemistry instructor before the student can handle them efficiently. The student should first be convinced of the advantages of scientific notation and should do a number of simple exercises before he attempts an equilibrium constant or a solubility product problem.

Though the application of these principles and techniques will not make good students of all those who enroll in elementary chemistry, it will help to reduce the number of failures and to develop in all the students the understanding needed in the more advanced courses.

MATHEMATICS IN THE MODERN SCHOOL PROGRAM

G. E. HAWKINS
Lyons Township High School, La Grange, Illinois

Those of us engaged in teaching during the 1930's, vividly recall the low esteem to which courses in mathematics sank for a time. In fact, in some schools, these courses were almost eliminated. Then during the war period, the situation was exactly reversed. Mathematics and science courses were heralded as all important. We worked furiously through short term refresher courses to teach certain essentials of mathematics as needed. The critics were stilled.

Today the demand for courses in high school mathematics continues. Frequently the question is asked whether or not the pendulum will swing in the near future to the other extreme and again these courses be proclaimed unnecessary or even useless. It seems to the writer that the mathematics teachers themselves, to a large extent, will be responsible for the answer.

Throughout a long period of history facility in the use of the mother tongue and facility in using numbers have been characteristics of the educated person. As our economic and industrial system grows more complex, the need for mathematics increases. The boy or girl ambitious in seeking self-advancement frequently needs a knowledge of the subject. The need is present. Can the teachers meet it adequately? Certainly this is no time for coasting along on the theory that mathematics is so essential that all must study it whether they want to or not. We must find ways to make the symbols and processes of the subject meaningful and the content vital. The use of abundant practical illustrations and problems will help.

The old adage "Nothing succeeds like success" is particularly pertinent. The pupil who understands what he is doing and who is succeeding in his work is much more willing to accept the teacher's statement that a given topic will be useful to him later. Unfortunately, in elementary mathematics, it is not always possible to furnish practice with practical applications to the extent we would like. However, we can make adjustments which enable a pupil to succeed with his work.

It is quite generally agreed that the same courses in mathematics cannot meet the needs of all pupils. The Second Report

of the Commission on Post-War Plans[1] makes some helpful suggestions on this topic. The report points out that the schools have a dual responsibility, "(1) to provide sound mathematical training for our future leaders of science, mathematics, and other learned fields, and (2) to insure mathematical competence for the ordinary affairs of life to the extent that this can be done for all citizens as a part of a general education appropriate for the major fraction of the high school population."[2]

Our traditional high school courses seem to meet training needs for our future leaders in science and mathematics quite well. At least objection to them for this purpose is slight. On the other hand, considerable difference of opinion exists regarding what we should do for the other pupils. Let us examine the Report of the Commission a little farther. It amplifies the meaning of functional competence in mathematics by means of questions in a check list of twenty-eight items. These include the ideas of fundamental operations, ratio, use of tables, approximate numbers, square root, graphs, common geometric concepts, rule of Pythagoras, basic geometric constructions, measurement, scale drawing, vector, metric units, symbolism of algebra, signed numbers, solving simple equations, similar triangles, meaning of trigonometric functions, verbal problems, and a basis for dealing intelligently with consumer problems arising at home and in business. The questions in the report make the objectives much more specific than this list of topics can indicate. This list of topics agrees quite well with the statements of the mathematics for minimum army needs issued during the war. Most of the material is also covered in the various courses in general mathematics or practical mathematics, which have become quite a common offering in high schools in the past decade. Without doubt, courses teaching this material have an important place in the curriculum. Whether one year, two years, or more in high school is spent on this job will probably vary from school to school. Certainly the characteristics of the student population, their abilities, needs, and plans for the future should be considered in deciding the particular course or courses to be offered.

In the school with which the writer is connected, the needs of the entering student who is unprepared for or who does not need traditional courses in algebra and geometry are met at present as follows. Such students are required to take one year

[1] *The Mathematics Teacher*, May 1945, pp. 195–221.
[2] Ibid., p. 195.

of general mathematics, a course which emphasizes most of the topics mentioned above in the Report of the Commission. That one-year course meets the requirements for the high school diploma. Later the students may elect the regular courses in algebra and geometry if they are prepared to do the work successfully. In practice about half of the pupils who take general mathematics continue with algebra the next year. Most of them succeed with the course. In the senior year these pupils may elect a course in social and business applications of arithmetic. The purpose of this course also is to aid in insuring mathematical competence for the ordinary affairs of life.

Offering two courses in mathematics to ninth grade pupils creates certain administrative problems. The procedure followed in this school, as an illustration, may be of interest. The pupils are assigned to either general mathematics or algebra instead of electing one or the other. The assigning is done during the summer by two mathematics teachers who make a careful study of the data on the pupils. These data are collected on regular high school record forms through the cooperation of the various elementary schools in the township which send pupils to the high school. They include an I.Q., an algebra aptitude score, and scores in reading and in arithmetic together with other school subjects in a test battery intended for the seventh and eighth grades. The eighth grade teacher also furnishes certain of her impressions about the pupil. Having this information, the ninth grade teachers can select, with very few errors in judgment, the pupils who should study general mathematics and those who should take algebra. The parents of the pupils who are selected for general mathematics are notified by letter in August and invited to call the high school office if they have questions. The pupils' needs and future plans are kept in the foreground in discussions with both pupils and parents.

Strange as it may seem, it is a rare exception for either a pupil or a parent to complain about an assignment to general mathematics. The general mathematics classes study approximately the same material as the algebra classes during the first two weeks of school, so that transfer is possible. After pupils get started in the general mathematics classes it is almost impossible to get them to transfer to algebra. Many of them have commented to the effect that for the first time in their school careers they could understand the things that they were doing in mathematics. Thus there seems to be no stigma attached to the course.

However, more important than the details in sectioning, is the need for a patient, understanding, well-qualified teacher supplied with suitable instructional materials. Whatever success the course may be having is due primarily to the latter.

In most of the better schools, a similar course is filling a genuine need of pupils. It is the success of these courses that may give us confidence to predict that mathematics can retain its important place in the curriculum. Success of the entire program depends upon the schools getting well qualified teachers to do the job and offering the variety of courses in mathematics that adequately meets pupils' needs.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

ONE HUNDRED SIXTY-FIFTH MEETING

Saturday, 8 February 1947
Massachusetts Institute of Technology, Cambridge, Mass.

9:30	Address: "Newton's Third Law," Prof. Francis Weston Sears M.I.T.
10:15	Address: "Polarized Light," Prof. Hans Mueller, M.I.T.
11:00	Address: "Production and Use of High Energy Electrons," Prof. Ivan Alexander Getting M.I.T.
11:45	Business Meeting
12:15	Luncheon at the Graduate House
1:15	Address: "The Electronic Differential Analyzer," Prof. Samuel Hawks Caldwell, M.I.T.
2:00	Apparatus Committee Report

Officers of the Association for 1946–47:

President: John T. Gibbons, Brighton High, Boston, Mass.
Vice-President: Anna E. Holman, Winsor School, Boston, Mass.
Secretary: Albert Thorndike Milton Academy, Milton, Mass.
Treasurer: Albert R. Clish, Belmont High School, Belmont, Mass.

Executive Committee Officers

Raymond F. Scott, Rindge Technical School, Cambridge, Mass.
Clarence W. Lombard, Hyde Park High School, Boston, Mass.
Mrs. W. W. Matheson, Cambridge Latin School, Cambridge, Mass

NEWTON'S THIRD LAW

Francis Weston Sears
Massachusetts Institute of Technology

Within a week or so from the time that our Freshmen begin their study of Mechanics, they are given the following problem: Part (a): A

block rests on a table. What two forces act on the block? What is the reaction to each force? Part (b): The block is given a push and slides off the end of the table. Neglecting air resistance, what force or forces act on the block while it is in flight between the table and the floor? What is the reaction to each of these forces?

Now this is not an exam and I do not propose to ask any questions of the audience, but before going any further I should like to have you all make a mental note of your answers to these two questions.

Newton's own statement of his third law reads thus: To every action there is always opposed an equal reaction; or the mutual actions of two bodies upon each other are always equal and directed to contrary parts.

The law is usually stated nowadays as, "Action and reaction are equal and opposite."

One of the unfortunate things about the statement of the third law is the use of the words "action" and "reaction." These terms refer, of course, to forces, and to bring in a synonym (or two synonyms) for the word "force" just at the stage when the student is first learning about forces, is scarcely good pedagogy. My first plea is therefore that Newton's third law be stated in terms of forces, and in words to this effect: "Whenever one body exerts a force on another, the second always exerts an equal and opposite force on the first."

That is, whenever body *A* exerts a force on body *B*, we find that body *B* exerts an equal and opposite force on body *A*. There are no exceptions to this law. It is equally true whether the bodies *A* and *B* are at rest moving with constant velocity, or are accelerated. If we wish to use the terms "action" and "reaction," then either of the forces may be considered the action and the other the reaction.

It is evident that an action and its corresponding reaction are never exerted *by* the same body, and never act *on* the same body. That is, if we consider the force exerted by body *A* on body *B* to be an "action," then the "reaction" to this force is the force exerted by body *B*, on body *A*. The action is exerted on body *B*, the reaction on body *A*. The action is exerted by body *A*, the reaction by body *B*. This answers at once the question that baffles many students, "If action and reaction are always equal and opposite, why do they not always cancel one another and leave no resultant force for accelerating a body?" Of course the answer is that the acceleration of a body is brought about only by forces exerted *on* that body (and exerted by bodies other than the one under consideration). If we consider any one of the forces acting *on* a body as an action, the reaction to this force is necessarily exerted *on some other body*. It may affect the motion of the other body, but it is not one of the set of forces acting on the first body and cannot be combined with the "action" to find the resultant force acting on the first body.

In order to find out what force constitutes the reaction to any given force, it is first necessary to make a clear statement about the given force, that is, to specify the body by which the force is exerted. Note carefully

that the *two* bodies concerned must be clearly recognized. It is not enough, for instance, to say that the weight of a brick is a force exerted on the brick by "gravity," or, if the brick is sliding along a table, to say that a force is exerted on it by "friction." "Gravity" and "friction" are not bodies, they are phenomena. The *body* which exerts a gravitational force on the brick is the earth, and the weight of the brick is a force exerted on the brick by the earth. The *body* which exerts a frictional force on the brick is the table on which it slides. Hence we begin with a statement such as: Force F is a force exerted by body A on body B. Then to find the reaction to the force F, which can be conveniently designated as F', it is only necessary to transpose the letters A and B in the first statement. That is, force F', the reaction to F, is a force exerted by body B on body A. Of course the forces F and F' are equal in magnitude and oppositely directed.

The procedure above may appear so simple as to be trivial, but it has been my experience that failure to follow this procedure is responsible for much of the confusion that has existed and still exists with regard to the third law.

A second common source of trouble in the application of the third law is merely a faulty process of logic. What it amounts to is confusing the third law with the first. An action and its corresponding reaction are, of course, equal and opposite, but it does not follow that just because two forces are equal and opposite they necessarily constitute an action-and-reaction pair. Suppose two railway porters are pushing two trucks in opposite directions on a platform, and each is exerting a force of 50 lb. on his truck. Few of us would select this example as an illustration of Newton's third law. It is true that the forces exerted by the porters are equal and opposite, but one is scarcely the reaction to the other.

Let us now return to the problem I suggested at the start of the discussion. Two forces act on the block at rest on the table, namely, its weight w acting vertically down and the upward push P exerted on the block by the table. These forces are equal and opposite, but I hope that none of you answered part (a) of the question by stating that upward push of the table is the reaction to the weight, because it is not.

In the first place, the forces P and W both act on the same body, while we have seen that an action and its reaction always act on different bodies. In the second place, suppose the table is quickly jerked out from under the block. The force W continues to act but the force P, which was exerted on the block by the table, drops out of existence. Then what has become of the reaction to W, since P can no longer be the reaction? I have received answers such as this: "Oh, the block now has a downward acceleration." The only response is, "So what?" Does the third law say that action and reaction are equal and opposite, except when a body is accelerated? No, there are no exceptions to the third law. The conclusion that P is the reaction to W is an example of the faulty logic referred to above. It is true that while the block is at rest on the table the forces P and W are equal and opposite, but it does not follow from this fact alone

that one is the reaction to the other any more than the force exerted by a porter on his truck is the reaction to another truck. How do we know that P and W are equal and opposite? Because the block is in equilibrium and the resultant force exerted on it is zero. But this is Newton's *first* law, not his third, and we know the forces are equal and opposite because the block is in equilibrium not because P is the reaction to W.

But if P is not the reaction to W, then what is the reaction to this force? Let us use the standard method for finding the reaction to a given force. The first step is to specify the given force, that is, state the body by which the force is exerted and the body on which the force is exerted. We therefore say "Force W is a force exerted by the earth (body A) on the block (body B)." Then to find the reaction to w, say w', we merely transpose bodies A and B and obtain the statement "Force W', the reaction to W, is a force exerted by the block on the earth." That is, the earth attracts the block and the block attracts the earth, with forces of attraction which are equal and opposite. The reaction to the weight of any body is a force of attraction exerted by the body on the earth.

It follows that force P never was the reaction to W, or in other words W was not the reaction to P. Then what was the reaction to P? We make the same sort of statement about P. "Force P is a force exerted by the table (body A) on the block (body B)." Then P' the reaction to P, is a force exerted by the block on the table. Since P is upward, P' is downward. When the table is jerked out from under the block, forces P and P' both drop out of existence.

A statement commonly heard is to this effect. "Suppose for concreteness the block weighs 10 lb. The statement is, "The weight of the block presses down on the table with a force of 10 lb." But the weight of the block is a force acting on the block, not on the table. It is true that the downward force exerted by the block on the table is 10 lb., but although this force is *equal* to the weight of the block, it is not the *same thing* as the weight. The weight of the block is the force we have called w, the downward push of the block on the table is the force P'. To show that they are equal we must use both the first and the third law. The fact that the block is in equilibrium tells us that $w=P$ (first law). The fact that P and P' are an action-and-reaction pair tells us that $P=P'$, and hence $P'=w$.

Incidentally, the block will press down on the table with a force equal to its weight only in the very special case where block and table are at rest or have no vertical acceleration. If two men take hold of the ends of the table and jerk block and table upward, that is, if the block has an upward acceleration, the force P must be greater than w to provide this acceleration. Then P', the reaction to P, is increased by the same amount that P increases.

To complete the answer to part (b) of our question, it should now be evident that the *only* force acting on the block while it is in flight from the table to the floor is its weight w. It is true that the block has velocity, acceleration, momentum, inertia, and energy, and it may be painted red

also, but these attributes of the block are not forces. The only force on the block is its weight w and the reaction to this force is the same as it was when the block was at rest on the table, namely, the force w' with which the block attracts the earth.

We now come to the more subtle type of error which confuses the third law with the second. If we write the second law in the form

$$F=ma,$$

or by an algebraic transformation

$$F=ma=0,$$

the error consists in calling the term $-ma$ a "reaction" or an "inertial reaction," and asserting that since this term is numerically equal to F and is opposite in sign, it therefore constitutes the reaction to F. So a common answer to part (b) of our question is to say that while the block is falling to the floor the reaction to its weight is the inertial reaction, $-ma$.

The possibility of writing the second law in the form

$$F-ma=0$$

was pointed out by D'Alembert. The D'Alembert method of handling problems in mechanics consists in adding to the vector sum of all the "real" forces exerted on a body a fictitious force $-ma$. When this force is included with the other forces, the resultant of *all* the forces is zero and a problem in dynamics can be handled by the methods of statics. Considered purely as a technique for problem solving, I have nothing against the D'Alembert method, but it is certainly no help to a student learning the principles of mechanics. He is told that while the block is at rest on the table the reaction to its weight is the force w', but as soon as it leaves the table the reaction changes to something else, the inertial reaction $-ma$. If he asks what about the force w', which now seems to be left out in the cold without any reaction (since w has another reaction of its own) of course there is an answer. While the block is accelerating toward the earth the earth is also accelerating toward the block, and the reaction to w' is the inertial reaction of the earth, say $-MA$. But now we see that if we identify ma and MA with the respective reactions to forces w and w', we have no principle remaining to tell us that w and w' are equal. We cannot use the first law, since the bodies are not in equilibrium, and w' is not the reaction to w.

Another objection to the D'Alembert method is that if it is used, the usual statement of the second law must be modified. The second law says that a resultant force, or an unbalanced force, is required to accelerate a body, and this resultant force equals the product of mass and acceleration. But according to D'Alembert the resultant force (including the inertial reaction) is zero in all circumstances, even when a body is accelerated. D'Alembert's method is merely another way of writing the second law and it should not be confused with the third. The term "inertial Reaction" should never be mentioned in elementary physics.

ABSTRACT OF AN ADDRESS ON "POLARIZED LIGHT"

By Hans Mueller

The following material pertains to the address on Polarized Light given by Professor Hans Mueller of M.I.T. on February 8. He introduced polarized light as an electromagnetic wave and showed the fact that there is very little difference between radio waves and light waves. As selectors of polarized light he used the calcite crystal; a set of photographic plates; a piece of quartz, and polaroids. He introduced the idea of the method of making two types of polaroids, one crystal in plastic (the use of polyvinyl alcohol) also cellophane heated until it will pull out under tension. This, he painted with ordinary iodine solution on both sides. He indicated the uses to which polarized light may be put. Under this discussion he pointed out that light has an electric vector; that blue light is turned to a greater degree than red light; that different colors produced by polarized light are due to the electrical content of the light. These, he illustrated by means of cellophane, quartz, and a cross section of a snail-shell. He showed, also, that by changing the plane of polarized light it can be made elliptical and thus be made to change colors. Some recent adaptations of polarized light are found in its use as a gun-sight, photography, and stereoscopic views in polarized light which gives the effects of a three dimensional picture.

ABSTRACT OF ADDRESS ON "PRODUCTION AND USE OF HIGH ENERGY ELECTRONS"

By Ivan Alexander Getting

Dr. Getting in his talk gave the various methods by which electrons may be accelerated. These, he classified as follows:

1. Electrostatic machines up to 100 million volts.
2. The Synchroton and the Betatron.
3. The Cyclotron.

He showed the mechanism of electrostatic machines capable of generating 10 million volts. This is essentially the Van deGraff machine. The Synchroton, he showed to be essentially a device to get the orbit of the electron in phase as an oscillator. The Betatron, he showed to be capable of going from 10 million up to 100 million volts. The Cyclotron, he showed to have the advantage of being very serviceable up to 10 million volts. The Betatron, is good for industry and radiology since it produces a narrow beam up to a few degrees. Therefore it is good for detecting flaws in metals.

Prof. S. H. Caldwell gave an interesting and instructive address on "A New Type of Differential Analyzer" which was previously discussed in the *Journal of the Franklin Institute*, Vol. 240, No. 4, October, 1945.

REPORT OF THE APPARATUS COMMITTEE

The work of the Apparatus Committee consisted in instructive demonstration by Mr. Charles Lewis, who showed how standing waves can be used to good advantage in the theory of electricity; Mr. Clarance Lombard demonstrated an unique siphon; Mr. John Brennen demonstrated an effective way for teaching the pendulum; and Mr. John Gibbons demonstrated how the Torricellian tube can be used in conjunction with the pressure gauge to teach Boyle's Law; also, demonstrated a home made piece of apparatus to show induction and Lenz's Law.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted n the best form will be used.

LATE SOLUTIONS

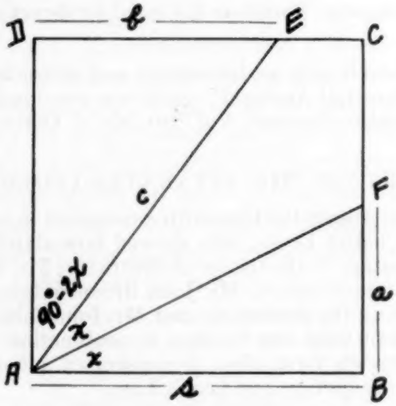
2018. *Hugo Brandt, Chicago.*
2019. *I. M. Gosz, W. DePere, Wis.; Daniel Pratt, Princeton, N. J.*
2020, 2. *Max Beberman, Nome, Alaska.*
2020, 1, 2. *M. Kirk, Philadelphia, Pa.*

2023. *Proposed by Hugo Brandt, Chicago.*

In a square $ABCD$ find point F on BC, and point E on DC so that $\angle BAF = \angle FAE$. Show that $EA = DE + FB$.

Solution by Norma Sleight, Winnetka, Ill.

By use of the figure,



$$\tan x = \frac{a}{s}$$

$$\tan(90^\circ - 2x) = \frac{b}{s}$$

$$a = s \tan x$$

$$b = s \tan(90^\circ - 2x)$$

$$\therefore \quad a+b = s[\tan x + \tan(90^\circ - 2x)]$$

$$= s\left[\tan x + \frac{1}{\tan 2x}\right]$$

$$= s\left[\tan x + \frac{1-\tan^2 x}{2\tan x}\right]$$

$$= s\left[\frac{\tan^2 x + 1}{2\tan x}\right]$$

$$= s\left[\frac{\dfrac{\sin^2 x}{\cos^2 x}+1}{2\dfrac{\sin x}{\cos x}}\right]$$

$$= s\left[\frac{\sin^2 x + \cos^2 x}{2\sin x\cos x}\right]$$

$$= \frac{s}{2\sin x\cos x}$$

$$\cos(90^\circ - 2x) = \frac{s}{c}$$

$$\sin 2x = \frac{s}{c}$$

$$c = \frac{s}{2\sin x\cos x}$$

$$\therefore \quad a+b=c$$

Solutions were also offered by Aaron Buchman, Buffalo, N. Y.; Frederick E. Nemmero, Milwaukee; Wm. A. Richards, Riverside, Ill.; R. A. Slack; V. C. Bailey, Evansville, Ind.; R. H. Brooks, Chicago; Mary Paula, Baltimore; Helen Scott, Baltimore; and the proposer.

2024. *Proposed by L. Jacobus, Kinderbook, N. Y.*

If in triangle ABC, $(a^2+b^2)\cos 2A = b^2-a^2$, show that the triangle is right angled.

Solution by Aaron Buchman, Buffalo, N. Y.

The theorem as stated, is incorrect.

$$\cos 2A = \frac{b^2-a^2}{b^2+a^2}.$$

By elementary trigonometry,

$$\frac{\cos^2 A - \sin^2 A}{\cos^2 A + \sin^2 A} = \frac{b^2-a^2}{b^2+a^2}.$$

By addition and subtraction,

$$\frac{\cos^2 A}{\sin^2 A}=\frac{b^2}{a^2} \quad \text{and} \quad \pm\frac{\cos A}{\sin A}=\frac{b}{a}\cdot$$

But in any triangle ABC,

$$\frac{\sin B}{\sin A}=\frac{b}{a}\cdot$$

Therefore, $\sin B = \pm\cos A$.

The following solutions are obtained from this relation.

Case 1: $B=90°-A$ where $0<A<90°$
Case 2: $B=90°+A$ where $0<A<45°$
Case 3: $B=A-90°$ where $90°<A<135°$

Since triangles in case 1 *only* are right angled, the proposed theorem is incorrect.

Note 1: The triangles in case 3 are those of case 2 with B and A interchanged.

Note 2: If the additional condition, $45° \leqq A < 90°$, is included in the proposed theorem, then the proposed theorem will be true.

Note. Hugo Brandt, Chicago gives a similar solution. Many solutions proved only the converse which is true.

2025. *Proposed by D. F. Wallace, St. Paul, Minn.*

If n is an even integer such that $n/2$ is the product of an odd number of twos and an odd number, then there is no square equal to the sum of n consecutive integers.

Solution by William A. Richards, Riverside, Illinois

Let a and b be any two odd numbers.

Then by hypothesis

$$n/2=2ab.$$

From the formula for the sum of an arithmetic progression we have

$$1+2+3+\cdots+n=n/2(1+n).$$

But

$$1+n=1+4ab$$

therefore

$$1+2+3+\cdots+n=2ab(1+4ab)$$

which obviously is not a square.

Solutions were also offered by R. A. Slack, Hugo; Brandt, Chicago; Harry Seller, Waterbury, Conn.

2026. *Proposed by Mildred Bitner, Brunswick, Me.*

The equation $x^5-209x+56=0$ has two roots whose product is unity. Find them.

Solution by V. C. Bailey, Evansville, Indiana

If the product of two roots is unity, then

$$x^2+kx+1 \tag{1}$$

is a factor of

$$x^5-209x+56. \tag{2}$$

The other factor, determined by division, has

(3) $$k^3-2k+56$$

for the remainder. There can be no remainder; therefore,

$$k=-4.$$

Then

(4) $$x^2-4x+1=0.$$

(5) $$x=2\pm\sqrt{3}.$$

A Second Solution by Harry Siller, Waterbury, Conn.

In

$$x^5-209x+56=0, \quad \text{replace } x \text{ by } \frac{1}{x} \tag{1}$$

$$56x^5+209x^4+1=0. \tag{2}$$

Now (1) and (2) have 2 common roots, which must be zeros of the highest common factor of left members. This H. C. F. is x^2-4x+1.

The roots of $x^2-4x+1=0$ are $z+\sqrt{3}$ and $z-\sqrt{3}$, and these are roots of (1).

Solutions were also offered by Cyprian Luke, Las Vegas, N. M.; Walter R. Warne, Dayton, Ohio; Joseph X. Brennan, Atlanta, Ga.; Paul Mont-Campbell, N. M. Military Institute; Hazel S. Wilson, Annapolis, Md.; Helen M. Scott, Baltimore; Wm. A. Richards, Riverside, Ill.; R. A. Slack; Norman Anning, University of Michigan.

2027. *Proposed by Charles King, Philadelphia, Pa.*

Solve:

$$(x+y)(x+z)=30$$
$$(y+z)(y+x)=15$$
$$(z+x)(z+y)=18$$

Solution by Hazel S. Wilson, Annapolis, Md.

(1) $$(x+y)(x+z)=30$$

(2) $$(y+z)(y+x)=15$$

(3) $$(z+x)(z+y)=18$$

Dividing (1) by (2), and (2) by (3), we have

(4) $$x-2y-\ z=0$$

(5) $$x+6y-5z=0$$

Solving (4) and (5) we have

$$x:y:z=4:1:2$$

Hence $x=4y$, $y=y$, $z=2y$.
Substituting in (1) we have

$$(4y+y)(4y+2y)=30$$
$$30y^2=30$$
$$y=\pm1$$
$$x=\pm4,\ y=\pm1,\ z=\pm2 \text{ (two solutions).}$$

Solutions were also offered by Wm. A. Richards, Riverside, Ill.; Frederick E. Nemmero, Milwaukee; Robert H. Brooks, Chicago; Raymond Kassler, Forest Hills, N. Y.; Joseph X. Brennan, Atlanta, Ga.; Hugo Brandt, Chicago; Margaret Joseph, Milwaukee; W. R. Warne, Edith M. Warne, Day-

ton, Ohio; Irving B. Kittell, Memphis, Tenn.; V. C. Bailey, Evansville, Ind.; L. R. Galebaugh, Lebanon, Pa.; J. F. Wagner; Walter L. Smith, Long Beach, Calif.; Helen M. Scott, Baltimore, Md.; Harry Siller, Waterbury, Conn.; Charles Haimbach, Langhorne, Pa.; R. A. Slack; Norman Anning, University of Michigan.

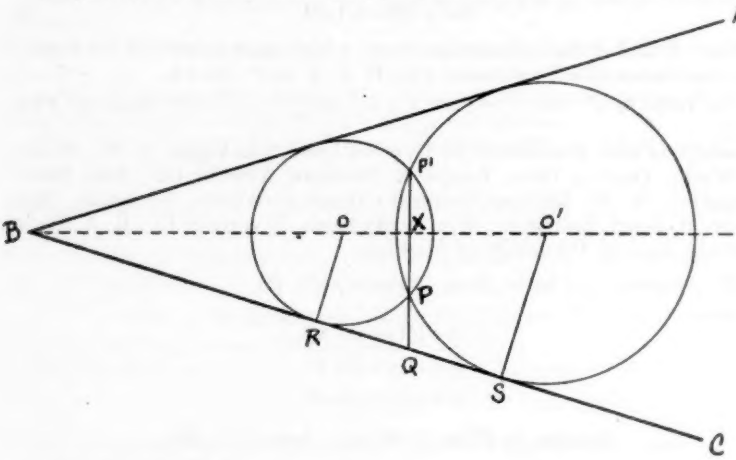
2028. *Proposed by Orville F. Barcus, Philadelphia.*

Through a given point within an angle, construct a circle tangent to two sides of the angle.

Solution by S. M. Gosz, W. DePere, Wis.

Given: $\angle ABC$ and point P.

BD, bisector of the given angle, is the locus of centers of all circles tan-



gent to the sides of the angle.

Construct $PX \perp BD$ and extend so that $PX = XP'$. Let $P'P$ intersect BC at Q.

RQ is the mean proportional between QP and QP'.

The length of RQ can be determined by construction. Construct $RO \perp BC$. Its intersection with BD determines the center of the required circle.

Circle O' also satisfies all the requirements. The proof is the same as for circle O.

Other solutions were by Norma Sleight, Winneka, Ill.; V. C. Bailey, Evansville, Ind.; Hugo Brandt, Chicago; Orville T. Barcus, Philadelphia, Pa.; W. A. Richards, Riverside, Ill.; R. A. Slack; Margaret Joseph, Milwaukee; Leonard L. Pate, Heppner, Ore.; Mary Paula, Baltimore; Walter L. Smith, Long Beach, Calif.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2028. *Bruce Herbert, Desplaines, Ill.*

2019. *W. E. H. Massey, Toronto.*
2027. *Dolores Lund, Mason City, Ia.; Robert J. A. Pratt, Mercersburg, Pa.; Frank Chasteler, Hammond, Ind.; Tom Swihart, Elkhart, Ind.*
2026. *Bill Holstein, Mercersburg, Pa.*

PROBLEMS FOR SOLUTION

2041. *Proposed by Roy Hancy, Ovid, N. Y.*

Solve:

$$\sqrt[3]{8x+4}-\sqrt[3]{8x-4}=2$$

2042. *Proposed by Hugo Brandt, Chicago.*

If $x+t+u=9$, $u>0$ and if $m=(10t+u)$, then show that $987654321m$ is a number of from 10 to 12 digits, in which the digits of the 12th, 11th and 1st place are the digits of m in the same order. Also show that the remaining nine digits are the same and equal to x.

2043. *Proposed by Lyman J. Harris, Maryville, Tenn.*

If

$$S_n=1+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\cdots+\frac{1}{n}$$

and n is greater than 2, then prove that

$$n(n+1)^{1/n}-n<S_n<n-(n-1)n^{-1/(n-1)}$$

2044. *Proposed by Norman Anning, University of Michigan.*

Prove that $[\sqrt{6}+\sqrt{4}+\sqrt{3}+\sqrt{2}+\sqrt{-1}]^{12}$ is a pure imaginary number.

2045. *Proposed by Hugo Brandt, Chicago.*

Show that, if the sum of squares of two integers is even, say $2S$, another pair of integers can be found, the sum of whose squares is S.

2046. *Proposed by Felix John, Philadelphia, Pa.*

Lines drawn from a vertex of a parallelogram to the mid points of opposite sides, trisect a diagonal.

BOOKS AND PAMPHLETS RECEIVED

MUSICAL ACOUSTICS, by Charles A. Culver, Ph.D., *Formerly Head of the Department of Physics, Carleton College.* Second Edition. Cloth. Pages xiv+215. 14.5×21.5 cm. 1947. The Blakeston Company, 1012 Walnut Street, Philadelphia, Pa. Price $3.00.

NEW TRIGONOMETRY INCLUDING THE ELEMENTS OF SPHERICAL TRIGONOMETRY, by Virgil S. Mallory, *Professor of Mathematics and Instructor in the College High School, State Teachers College, Montclair, New Jersey.* Cloth. Pages vii+264. 13×19 cm. 1947. Benj. H. Sanborn & Company, 221 East Twentieth Street, Chicago 16, Ill. Price $2.00.

CONCISE CHEMICAL AND TECHNICAL DICTIONARY, Edited by H. Bennett, *Technical Director, Glyco Products Company, Inc.* Cloth. Pages xxxix+1055. 15×23 cm. 1947. The Chemical Publishing Company, Inc., 26 Court Street, Brooklyn 2, N. Y. Price $10.00.

DOORWAYS TO SCIENCE, by George W. Hunter, Ph.D., *Lecturer in Methods of Science Education, The Graduate School Associated Colleges at*

Claremont, Claremont, California, and Walter G. Whitman, A.M., *Formerly Head, Physical Science Department, State Teachers College, Salem, Massachusetts*. Cloth. Pages xiii+546. 15.5×22 cm. 1947. American Book Company, 88 Lexington Avenue, New York 16, N. Y. Price $2.40.

SCIENCE, A STORY OF DISCOVERY AND PROGRESS, by Ira C. Davis, *Professor in the Teaching of Science, School of Education, University of Wisconsin, Head of Department of Science, University High School*, and Richard W. Sharpe, *Formerly Instructor in Science, George Washington High School, New York City*. Cloth. Pages xiii+538. 15×23.5 cm. 1947. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price $2.36.

APPLIED CHEMISTRY, by Sherman R. Wilson, *Head of the Exact Science Department, Northwestern High School, Detroit, Michigan*, and Mary R. Mullins, *Chairman of Physical Science, Midwood High School, Brooklyn, New York*. Revised. Cloth. Pages xxi+714. 1947. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price $2.36.

ON UNDERSTANDING SCIENCE, AN HISTORICAL APPROACH, by James B. Conant, *President of Harvard University*. Cloth. Pages xiii+145. 13×20.5 cm. 1947. Yale University Press, New Haven, Conn. Price $2.00.

A LABORATORY MANUAL OF VERTEBRATE EMBRYOLOGY, by F. B. Adamstone, Ph.D., *Professor of Zoology, University of Illinois;* and Waldo Shumway, Ph.D., *Professor of Zoology, University of Illinois*. Second Edition. Paper. Pages vii+96. 21×28 cm. 1947. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $2.00.

COURSE OF STUDY IN PHYSICS, Grades Eleven and Twelve, Prepared by a Committee, W. Harold Evans, *Chairman*. Curriculum Bulletin 120. Paper. Pages iii+88. 20.5×27.5 cm. 1944. Cincinnati Public Schools, Cincinnati, Ohio.

MULTIPLE-FACTOR ANALYSIS, A Development and Expansion of the Vectors of Mind, by L. L. Thurstone, *The University of Chicago*. Cloth. Pages xix+535. 15×23 cm. 1947. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $7.50.

SCIENCE THROUGH EXPERIMENT, A General Science Workbook by Charles H. Lake, *Superintendent of Public Schools, Cleveland, Ohio;* Louis E. Welton, *Assistant Principal, Formerly Head of Science Department, John Hay High School, Cleveland, Ohio;* and James C. Adell, *Chief, Bureau of Educational Research, Public Schools, Cleveland, Ohio*. Paper. Pages viii+264. 19.5×26 cm. 1947. Silver Burdett Company, 45 East 17th Street, New York 3, N. Y. Price $1.24.

INVESTIGATION OF PETROLEUM RESOURCES (New Sources of Petroleum in the United States). Printed for the Use of the Special Committee Investigating Petroleum Resources. Paper. Pages iii+539. 14.5×23 cm. 1945. United States Government Printing Office, Washington, D. C.

WARTIME PETROLEUM POLICY UNDER THE PETROLEUM ADMINISTRATION FOR WAR. Printed for the Use of the Special Committee Investigating Petroleum Resources. Paper. Pages iv+180. 14.5×23 cm. United States Government Printing Office, Washington, D. C.

PETROLEUM REQUIREMENTS—POSTWAR. Printed for the Use of the Special Committee Investigating Petroleum Resources. Paper. Pages iii+119. 14.5×23 cm. 1945. United States Government Printing Office, Washington, D. C.

MINERALS, ROCKS AND SOILS. Catalog 474. 44 pages. 15.5×23 cm. 1947· Ward's Natural Science Establishment, P.O. Box 24, Beechwood Station, Rochester 9, N. Y.

SCIENTIFIC PERSONNEL BULLETIN. Employment Series No. 6. SPB Series No. 13. January–February, 1947. 76 pages. 20×27 cm. Navy Department, Office of Naval Research, Scientific Personnel Branch, Washington 25, D. C.

THE ROCKEFELLER FOUNDATION. A Review for 1946, by Raymond B. Fosdick, *President of the Foundation*. Paper. 64 pages. 15×23 cm. The Rockefeller Foundation, 49 West 49th Street, New York 20, N. Y.

THE STRUGGLE FOR ATOMIC CONTROL, by William T. R. Fox. Public Affairs Pamphlet No. 129. Public Affairs Committee, Inc., 22 East 38th Street, New York 16, N. Y. Price 20 cents.

BOOK REVIEWS

PRACTICAL BIOLOGY, by Edwin F. Sanders, *Washington Park High School, Racine, Wisconsin*. Cloth. Pages viii + 618. 15×23 cm. 445 illustrations. 1947. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y. Price $3.00.

The subject matter of this text has been organized according to what has been considered standard treatment—that of presenting the plant and animal science separately for the most part. Some teachers will prefer this text for this reason. Others will not, as it does not follow the recent trend of bringing the various plant, animal, and human facts and relationships to light under the same broad unit headings of vital biological principles.

The author devotes 10% of his text to introduction and fundamentals, about 30% each to plant and animal science, about 20% to conservation, development, and heredity, and 10% to the human body. There is a 11-page index. There is no glossary but the careful explanation given to new terms, as they appear, is worthy compensation. The illustrations, which are numbered and subnumbered according to chapter, includes numerous line diagrams and sketches.

Most commendable are the author's varied thought-and-interest-provoking activities at the end of each chapter. These activities always come under the same three headings: "Do you Remember What The Chapter Was About? Do You Want To Test Yourself?" and "Things Which You Might Like To Try."

Those not wishing to use this book as a class text will want to have some copies on hand as classroom reference texts.

J. MCMENAMIN

VITALIZED GENERAL SCIENCE, by Barclay M. Newman. Paper. Pages, iv+380. 13.5×18.5 cm. 1947. College Entrance Book Company, New York.

This book covers the usual topics of general science in a brief but adequate manner. The opening chapter stresses the scientific method and the associated attitudes but fails, like most other books in science, to continue the stress on the scientific method and attitudes throughout the book. Few books stress controls and variables in science experiments and this book is no exception.

One of the outstanding features of this book is the colored diagrams and illustrations. In fact, these diagrams alone are worth the price of the book. Many of the diagrams illustrate difficult science concepts so well, that it would be good technique to throw the diagrams on a screen with an opaque projector.

The chapter summaries and review questions are well done. The appendix has a good summary of the basic principles of first aid. This book alone, however, would hardly be sufficient for a comprehensive course in general science.

KENNETH E. ANDERSON

NEW WORLD OF CHEMISTRY, by Bernard Jaffe. Cloth. Pages ix+710. 15.5×22.5 cm. 1947. Silver Burdett Company, New York, New York, Price $2.?8.

Most teachers of high school chemistry will find this book an excellent one for classroom work. This edition is thoroughly up to date. One chapter tells how scientific methods led to the release of atomic energy. The book abounds in excellent diagrams, illustrations, and pictures. The subject matter is keyed to everyday living and touches the student's own daily environment.

The chapters on formula writing, equation writing, and problem solving are excellent. Each of the chapters furnishes sufficient practice work to give the average student a good mastery of these essential tools of chemistry.

At the end of each chapter the teacher will find excellent aids for individualizing her instruction. "You Will Enjoy Reading" lists some excellent books and magazine articles for those who wish to go beyond the text. "Useful Ideas Developed" stresses the basic principles and generalizations of the chapter. "Using What You Have Learned" gives students the opportunity to use scientific methods in many kinds of problems of everyday living. "Projects, Activities, and Investigations" suggests topics for further investigation. These end-of-the-chapter suggestions and exercises are excellent aids to the busy teacher.

In line with the modern trends in education, this book lists seventeen distributors of educational films. Some one-hundred and fifty films covering numerous subjects in Chemistry provide the teacher with an excellent choice of films.

Here is a book that makes provision for the terminal student as well as the student who plans on going to college.

KENNETH E. ANDERSON

AVIATION EDUCATION; TEACHERS' GUIDE. Paper. Pages v+132. 21.5×28 cm. 1946.

FUNDAMENTALS OF AVIATION. Paper. Pages iv+107. 21.5×28 cm.

THE LINK TRAINER AS A CLASSROOM DEMONSTRATOR. Paper. Pages 52. 21.5×28 cm.

These publications are offered by Link Aviation Devices, Inc., of Binghamton, N. Y., makers of the Link Instrument Trainer, widely used in mil-

itary and civilian instrument flight training, to "stimulate thought and interest in general aviation on the secondary level." They represent the recommendations of a group of educators with experience in the military Air Forces.

"*Aviation Education—Teachers' Guide*" is precisely what its title indicates—a comprehensive outline for a one year course at the secondary level covering all phases of general aviation education. Eight units with the titles: Air Age, Airplane Structures, Powerplants, Why An Airplane Flies, How An Airplane Is Flown, Weather, Navigation, and Communication and Control are presented. Each unit is arranged to show Aim, Objectives, Course Content, Methods, Time Allotment, Visual Aids, and Selected References.

"*Fundamentals of Aviation*" is an outline text of an elementary course in Aviation following in general the arrangement of the "Teachers' Guide" as to subject matter. It is well illustrated, and in a clear, concise manner presents for the beginner the story of aviation.

"*The Link Trainer as a Classroom Demonstrator*" presents detailed suggestions for the installation, use and maintenance of the Link Trainer. In the military services the Trainer was an Instrument Flight Trainer, and certain minor changes to be made to adapt it to classroom use and the technique of instruction are adequately presented. A "Syllabus for Individual Instruction" outlines the lessons suggested.

These books form a valuable addition to the literature of Aviation Education, and should be found very helpful to the teacher of Aviation Science or General Aviation. Link Aviation Devices, Inc. are to be commended for these contributions to the field of education. These publications are being revised at frequent intervals, and the last two are not dated. "Fundamentals of Aviation" is priced at $1.00, with an educational discount available to teachers.

RUSSEL B. DANIELS
Oak Park, Illinois

ENDLESS HORIZONS, by Vannevar Bush. Introduction by Dr. Frank B. Jewett. Cloth. Pages viii+182. 15×23 cm. 1946. Public Affairs Press, 2153 Florida Avenue, Washington 8, D. C. Price $2.50.

As Director of the Office of Scientific Research and Development during the war, Dr. Bush was in a unique position of influence and observation of the scientific progress of the country, during the period of greatest acceleration of scientific achievement that the world has ever known. During this time Dr. Bush made many addresses and wrote many articles pertaining to the technological status and future prospects of this country and its scientists and engineers. This book is a summarization of many of these articles, which endeavor to bring our national thinking out of "The Inscrutable Past" to the "Endless Horizons" of a new way of life through properly directed and financed scientific research.

Before reading the book, one must read Dr. Frank Jewett's brief but interesting appraisal of Dr. Bush's life. Unless the reader is already acquainted with Dr. Bush's active inventor's mind they will not be able to evaluate the author's "Inscrutable Past" of the Nineteen Thirties nor his peep into the future in his "As We May Think." It is difficult for the ultimate consumer to distinguish much between his present late Nineteen Forties, which were a part of Dr. Bush's future, and those inscrutable Thirties. Reconversion has brought the motor car of the thirties with a new grille; the refrigerator of the thirties with one or two new compartments; the radio of the thirties minus a few items, and all at a higher price which

places them out of the reach of most of the men who created them.

Dr. Bush's excursion into the possibilities of the future would be discounted as fantastic were it not for the known accomplishments of the author in these same fields. These things, here revealed, must be a part of the "Endless Horizons" just as radar and jet propulsion; electronic calculators and atomic bombs; have already surpassed Buck Roger's wildest dreams. Yet, where is radar at our civilian airports?

Dr. Bush's visualized progress is that of a controlled economy of limitless resources such as a democrary has only in times of war, but which slows to a snail's pace under the reaction of laissez faire economic competition of peace time. His vision of the professionalized engineer, of government support for research, and reforms in our patent system are all sound and should be read by every engineer, scientist, legislator, and teacher. Is Dr. Bush's plan more than the "American Way of Life" in peace time will support, or are the Fifties and Sixties to be inscrutable?

H. R. VOORHEES
Chicago Junior College, Herzl Branch

FROM GALILEO TO THE NUCLEAR AGE, by Harvey Brace Lemon, Ph.D., *Professor of Physics, The University of Chicago; Curator of Physics, Museum of Science and Industry, Chicago.* Revised Edition of *From Galileo to Cosmic Rays.* Cloth. Pages xi+451. 16.5×23 cm. 1946. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill. Price $3.75 Text Edition; $5.00 Trade Edition.

Here is a new edition of a popular survey of physics covering the classical principles from Galileo's time to ultramodern theories of the "Nuclear Age."

All of the excellent things said of the original book concerning its novel and readable presentation may be repeated for this edition, and well they may for there is no detectable change in form, wording or paging until page 313 where the isotope is placed on a quantitative foundation and the neutron is placed in its more certain position with the building blocks of nature.

It is interesting to see how skillfully the author has faded the men and works that were ultramodern twelve years ago, into the background, and replaced them with the men and their works in artificial nuclear disintegration that has brought us the "Nuclear Age." This new story has been inserted without disrupting the old page numberings by extending page 330 from a to i.

A brief account of radar has been introduced with scarcely a ruffle of the paragraphs, but don't miss the revision of the accompanying diagram to show the ultra high frequency waves getting through the reflecting layer and striking the moon.

The author must be complimented that the presentation of the old principles in the first edition required no change for clarity or accuracy of statement. It must be again said that this is probably one of the most "delightful textbooks" about physics, and it is hoped that it will continue to lead the novice to the classrooms and laboratories of science to learn physics.

H. R. VOORHEES

ELEMENTS OF SOIL CONSERVATION, by Hugh Hammond Bennett, *Chief, Soil Conservation Service U. S. Department of Agriculture.* First Edition. Cloth. Pages x+406. Photographs, Maps, Graphs and Tables. 21×14.5 cm. 1947. McGraw-Hill Book Co., Inc. 330 West 42d Street, New York, 18, N. Y. Price $3.20.

An excellent textbook for students and a valuable handbook for all interested in the problems of soil conservation. It brings together basic ideas and latest techniques in solving soil and water conservation problems.

It does more than present the physical aspects of erosion. It relates them to economic and social consequences which have direct bearing upon such things as tenancy, taxes and community life. It constantly emphasizes the fact the "productive soil is the most basic asset of the nation" and that "soil conservation is not just an incidental bit of the mechanics of farming; [but is] part and parcel of the whole business of making a living from the land and is the only way by which we may have permanently productive land for a permanent agriculture to support a permanent nation."

The book presents material which is not available in other texts. It presents this material in a way that is easily understood. Numerous pictures and diagrams supplement the text and add to its understanding and interest.

Each of the 22 Chapters of the book has a set of comprehensive questions and a list of references. The book also provides a "List of Visual Aids," films and filmstrips, arranged by Chapters. This list furnishes the film title, a brief synopsis and information concerning running time, nature of film, whether sound or silent, or whether in color or black and white. The sources of these visual aids is also given.

Villa B. Smith
John Hay High School, Cleveland, Ohio

Chemistry for Our Times, by Elbert Cook Weaver, M.A., *Instructor, Phillips Academy, Andover, Massachusetts;* and Laurence Standley Foster, Ph.D., *Formerly Assistant Professor of Chemistry, Brown University, Chief, Powder Metallurgy Branch, Research Division, Laboratory Department of Watertown Arsenal, Watertown, Massachusetts.* Cloth. Pages xii+738. 15×22.5 cm. 1947. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $2.48.

Three unique publications for use by high school students of chemistry have appeared the last seven years. Jaffe's *New World Chemistry* has recently been revised; Ahrens, Bush and Easley's *Living Chemistry* appeared in 1942 and Weaver and Foster's *Chemistry for Our Times* bears the imprint of 1947.

These books are different, particularly the last two, in that they unblushingly bid for pupil interest rather than the approval of the technical chemists. Ahrens, Bush and Easley have probably been embarrassed, at times, by its obvious heirship to the progressive educationists' formula. Weaver and Foster have, happily, used many assets of that school of teachers cloaked, however, under a more conventional presentation. The product is a teaching tool of truly original design. By the use of attractive illustrations, some in color and all of a size to give clarity to their purpose, by skillfully executed diagrams that teach, even without legends and anecdotal narrative, the authors invite the unwary student to try to scan and in the end he continues perusal of text as well as pictures. Not since the day of Steele's *Fourteen Weeks of Physics* has the reviewer found such successful use made of brief tales of occurrences associated with significant events in the story of a science.

The authors, in the preface, set forth an ambitious program for the book. Careful inventory of the chapters that follow that preface soon convince the reader that the preface was probably written after and not before the copy was sent to the compositor. That preface is more than "window dressing."

The presentation is in terms of nine units, including: Our essential environment; Dispersions of matter; The earth's crust; Chemical industries; The metals; Carbon compounds and Chemistry; and Human problems. Its claim to "(meeting) regular course requirements (by) covering all the fundamentals" appears to be borne out when a careful inventory of its offerings has been made.

Without wishing to detract from other excellences of this book attention should be directed to its teaching aids. Mention has already been made of its illustrations which teach as well as illuminate. Generous offerings of exercises are so distributed that they are not too removed from the principles they are supposed to apply. In these exercises provision is made for drill, for association with natural as well as community setting and for some practice in applications that require some sense of quantity as well as quality. Vocabulary lists are provided as the presentation proceeds and a good glossary and an ample index are time savers for both teacher and pupil.

It is the considered judgment of the reviewer that any high school teacher of chemistry who is contemplating a change in textbooks should, by all means, include this book in the list of those to be considered before making recommendation for an adoption.

B. Clifford Hendricks
University of Nebraska, Lincoln, Neb.

Communication Through the Ages, by Alfred Still, *Fellow, American Institute of Electrical Engineers; Member, Institution of Electrical Engineers.* Cloth. Pages 201. 14×21.5 cm. 1946. Murry Hill Books, Inc., 232 Madison Avenue, New York 16, N. Y. Price $2.55.

This is the third, and in some respects, the best of the three recent books written by Mr. Still and published by Murray Hill.* It is not just a chronicle of the growth of communication at a distance, but it is filled with choice thoughts and pithy comments which prove that a man can be much more than an engineer or a teacher of the principles of engineering. In the first few pages he quickly runs through the early attempts to send messages to distant points by fire, smoke signals, drums, the army signaling mast of early American history, Robert Hooke's optical telegraph, Claude Chappe's semaphore signal tower and Murray's six-shutter telegraph, taking the reader on to the beginning of the electrical age. Here the author shows the rapid development of the knowledge of electricity and its applications for communication at great distances made in all the leading countries of the world. Many of us in Amerida think only of Morse when the invention of the telegraph is mentioned. Mr. Still thinks and writes of Morse and of his many contemporaries. In Chapter VII he tells the interesting story of Cyrus W. Field and William Thomson in laying the Atlantic cable. This is followed by the story of the telephone, patented by Alexander Graham Bell, the teacher of music and speech. Here again the author tells of the contribution of Elisha Gray and others working toward the same end. Next is the story of radio telephony preceded by the mathematical theory of Maxwell but put into more understandable language for most people by Hertz. Marconi, Fleming, de Forest and a host of others are credited with their contributions. A brief discussion of the new field of television brings the story up to date.

These books by Professor Still are so valuable they should be made up in more lasting form than conditions permit during wartime shortages.

G.W.W.

* The two books reviewed in earlier numbers are *Soul of Amber* and *Soul of Lodestone.*

A TEXTBOOK OF QUALITATIVE ANALYSIS, by William Buell Meldrum, *Professor of Chemistry, Haverford College, Haverford, Pennsylvania,* and Alfred Frederick Daggett, *Professor of Chemistry, University of New Hampshire, Durham, New Hampshire.* Cloth. Pages xi+431. 14×22 cm. 1946. American Book Company, 88 Lexington Avenue, New York 16, N. Y. Price $3.50.

While it is unfortunate that qualitative analysis, at best a well-motivated course for the introduction of the students to a study of chemical principles and the properties and reactions of ions, continues to be taught as a separate unit, many of its texts are models of excellence in organization and correlation of theory and practice. The authors have produced such a text. Its theory is quite sound and includes a modern treatment of atomic theory and valence, a conventional but very good discussion of reactions in solution, first qualitatively and then mathematically, electrochemistry, oxidation-reduction, and colloids.

The laboratory procedure for cations follows the usual pattern but with NaHS reagent used to separate the ions of Group II. The usual troublesome procedures for the alkaline earths are followed. The anion analysis section is brief but about as systematic as it is possible to make it.

The excellent features include a discussion of the shortcomings of the solubility product principle, preliminary experiments which are designed to lead to a scheme of separation and identification, excellent references, and a summation of all of the pertinent ionic reactions. The weak points, which are perhaps in part due to the elementary nature of the course for which the text is designed, include a rather poor treatment of strong electrolytes and the salt effect, and a lack of an adequate number of problems.

In all it is a very good text for qualitative analysis, and is adaptable for use in a one year course in general chemistry which includes qualitative analysis.

A. L. BURLINGAME
Chicago City Junior College, Wilson Branch

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THE ELECTRONIC THEORY OF ACIDS AND BASES, by W. F. Luder, *Associate Professor of Chemistry* and Saverio Zuffanti, *Associate Professor of Chemistry, Northeastern University, Boston, Massachusetts.* Cloth. Pages ix+165. 13.5×21 cm. 1946. John Wiley and Sons. Inc., 440 Fourth Avenue, New York 16, N. Y. Price $2.75.

The authors have in this text combined the material of their previously published papers with other material in a laudable attempt to summarize the theory of acids and bases first proposed by Gilbert N. Lewis in 1923 and now known as the electronic theory. After a brief discussion of the theories of Arrhenius (water), Franklin-Germann (solvent systems), Bronsted-Lowry (proton) and Usanovich (positive-negative), and a review of the several types of valence, the Lewis theory is developed. A treatment of the relationship of acid-base to the solvent, typical reactions, and an extension of acid base phenomena beyond any one solvent or element follow.

The main theory, namely that an acid is "capable of accepting a share in a lone electron pair from a base to form a coordinate covalent bond," is developed on the basis of the four experimental criteria cited by Lewis: neutralization, titration with indicators, displacement, and catalysis. Each of these topics is developed rather fully, well illustrated by examples, and interpreted on the basis of the electron theory. Four chapters on catalysis are of special interest to the organic chemist.

That such a summation of acid base theory is needed is obvious; the

authors have admirably succeeded in their attempts to present clearly and rather completely this somewhat neglected phase of acid-base theory.

A. L. BURLINGAME

SMITH'S COLLEGE CHEMISTRY, by William F. Ehret, *Professor of Chemistry, New York University*, N. Y. Sixth Edition. Cloth. Pages xii+677. 17×25 cm. 1946. D. Appleton-Century Company, 35 West 32nd Street, New York, N. Y Price $4.75.

The sixth edition of *Smith's College Chemistry* by Ehret has the same guiding principle as that enunciated by the late Alexander Smith in the first edition and followed so carefully by Kendall in the third, fourth, and fifth editions: "No conception is defined, and no generalization or law is developed, until such a point has been reached that applications of the conception and experimental illustrations, later to be related in the law, have already been encountered." Consistently the evidence is clearly presented before the student is asked to draw conclusions and to make generalizations. Laws presented in this fashion do not appear to be the arbitrary decisions of chemists of earlier days.

The book is divided into fifty-two chapters each of which may be covered in one or two one-hour lecture periods. The sequence of topics is conventional and similar to that found in the earlier editions, although the content of many of the chapters has been extensively revised. Atomic structure is introduced in chapter IV although it is not covered in detail until chapter XIX. The section on radioactivity and the transmutation of the elements has been modernized to include a discussion of the atomic bomb.

The chapter, "Newer Concepts of Acids and Bases," takes up the Brönsted system in detail and mentions the Lewis non-protonic acid system

The material is accurately and interestingly presented. It is adaptable to either the tutorial or lecture system of presentation. The questions at the end of each chapter have been extensively revised from those of earlier editions. References to current periodicals are provided at the end of each chapter. From any point of view this is an excellent college text.

A. L. BURLINGAME

CHEMICAL SPECIALITIES. A Symposium Compiled by H. Bennett, *Technical Director, Glyco Products Company, Inc.* Cloth. Pages xiv+826. 13.5×21.5 cm. 1946. The Chemical Publishing Company, Inc., 26 Court Street, Brooklyn 2, New York. Price $12.50.

This book is far more than a chemical formulary. It covers every aspect of the chemical specialty business (stain removers, cosmetics, etc.), from the choice of the product to be compounded to its proper packaging and successful marketing. The book contains sufficient information to enable the non-technically trained business man to understand chemical compounding and the chemist to secure necessary business information.

The book consists of eleven chapters and an appendix. The first six chapters treat of the production aspect of the chemical specialities business covering such topics as the definitions of chemistry and the physical properties of chemicals; classification of chemicals by chemical properties; classification of chemicals by use; raw materials; processing procedures and equipment; and the composition of various chemical specialities. The chapter on processing and equipment discusses the difficulties encountered in packaging and labeling a product and would prove of great value to the chemist setting up his own business. The formulary is extensive.

Chapters VII to XI are concerned with the business aspects of the small

chemical business—marketing; general business principles; records and forms; technical help; laws and regulations. The latter section covers the Federal Food, Drug, and Cosmetic Act; the Federal Caustic Poison Act; and the Federal Insecticide Act.

The appendix is of particular value to both the chemist and the business man. Among the topics which it includes are the common hazardous chemicals; conversion tables such as specific gravity to pounds per gallon; equivalents on various specific gravity scales. It contains a list of over six hundred distributors of chemicals and information on the chemicals which each of them can supply.

A. L. Burlingame

Basic Mathematics for Technical Courses, by Clarence E. Tuites, *Instructor in Electricity and Mathematics, Rochester Institute of Technology*. Cloth. Pages xiv+343+132. 14.5×23 cm. 1947. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $5.00.

This text, besides being theoretically accurate and comprehensive, makes a significant contribution to the teaching of applied mathematics. The author has achieved a fine balance between college general mathematics as a foundation for advanced work and as a tool in trades and industries. Out of a total of 1326 exercises, 341 are of a concrete nature culled from industry and science. The remainder are of the drill type to produce skill and mastery of the material.

One example of the planning that has gone into the text is the assignment schedule in the rear of the book. The problems in most chapters are divided into three assignments of equal length and difficulty. Any one assignment is sufficient for acquiring an understanding of the material, and yet additional drill may be given where needed. A section of answers to exercises places emphasis on procedure and method, where it belongs.

Besides an answer key, there are several other features of the book that will serve to make it self-contained and useful in industrial schools and for self-study. Some of these features are tables of logarithms of numbers, logarithms of functions, natural trigonometric functions, natural logarithms, squares and square roots, and decimal equivalents of common fractions.

The written text stands up well under a close scrutiny for ambiguities and vague passages. Where the discussion itself might be inadequate, a nearby diagram makes the material clear. To the reviewer, one of the outstanding points is that mathematical derivations of formulas are accompanied step by step with terse, appropriate, explanatory phrases that makes self-study easier.

Finally, the mathematical coverage of the text can be judged to some extent by an examination of the chapter headings: the slide rule, arithmetic with applications, the fundamental operations in algebra, equations and formulas, graphical representation, logarithms, angles and functions of angles, the right triangle, functions of angles of any magnitude, functions of two angles, the sine and cosine laws with applications, additional trigonometric principles and applications.

Being bound in cloth and well printed, the book is worth consideration as a text on the beginning college level and as a reference work and source book on the high school level.

Sheldon S. Myers
Western State High School, Kalamazoo, Michigan

MATHEMATICS INSTITUTE

Duke University
August 5–15

W. W. RANKIN, *Director*, Duke University
VERYL SCHULT, *Assistant Director*, Washington, D. C.

General Theme—Mathematics at Work
(Junior and Senior High School and College)

PROGRAM

August 5, Tuesday 9:00 A.M.–1:00 P.M. Registration

2:30–4:00 P.M.

"The Epic of Mathematics" (Mural Paintings)
Miss Clare Leighton, English American Artist
Professor W. W. Rankin, Director of Mural Paintings
Organization of Study Groups
Miss Veryl Schult, Supervisor of Mathematics, Washington, D. C.

8:00–9:30 P.M.

"Atomic Power"
(Speaker to be announced)
Discussion

August 6, Wednesday 11:30 A.M.–12:30 P.M.

"Some Applications of Mathematics to the Problem of Tire Industry"
Mr. R. D. Evans, Mathematician, Goodyear Tire & Rubber Co., Akron, Ohio

6:30 P.M.

Banquet—Presiding, Dean Herbert Herring, Duke University
"Ways and Means of Closer Cooperation Between Industry and Education"
Mr. R. E. Gillmor, Vice President, Sperry Gyroscope Corporation
"Education and the New Industry"
Dr. Dwayne Orton, Educational Director, International Business Machines Corp.

9:00–10:00 P.M.
Social Hour

August 7, Thursday 11:30 .A.M–12:30 P.M.

"Approach to Study of Research Problems"
Mr. A. F. Underwood, Head Division 5 Mechanical Engineering, General Motors Research Laboratories
Discussion

8:00–9:45 P.M.

"Mathematics in the Study of Bearings"
Mr. A. F. Underwood, General Motors Laboratories
"Making and Using, Films, Instruments, and Models in the Study of Mathematics"

Mr. Roger W. Zinn, Educational Consultant, Jam Handy Organization
Discussion

August 8, Friday 3:30 P.M.
Visit to Wright Automatic Machinery Co.

8:00–10:30 P.M.

Party—University House
"Science, Industry, Mathematics and Standards of Measure"
Dr. Edward U. Condon, Director of Bureau of Standards, Washington, D. C.

August 9, Saturday 11:30 A.M.–12:30 P.M.
"Vital Statistics in Relation to Life Insurance
Dr. Alfred J. Lotka, Statistician, Metropolitan Life Ins. Co., New York City
Discussion

6:00 P.M. Dinner
Dinner—Movie ("Meet North Carolina")

"Modern Trends in Mathematical Education"
Professor W. D. Reeve, Columbia University

August 10, Sunday 5:00 P.M.
Tea—Rankin Home

August 11, Monday 11:30 A.M.–12:30 P.M.
"Mechanisms and Mathematics"
Mr. Glenn M. Tracey, Chief Research Engineer, Wright Automatic Machinery Co.
Discussion

8:00–9:45 P.M.

"Engineering Methods of Study"
Professor C. R. Vail, Electrical Engineering, Duke University
"Practical Uses of the Limit Concept"
Professor C. G. Mumford, Mathematics, N. C. State College
Discussion

August 12, Tuesday 11:30 A.M.–12:30 P.M.
"The Uses of Probability in Manufacturing"
Mr. D. K. Briggs, Chief of Sounds Instruments Engineering Department, Western Electric Co.
Discussion

6:00 P.M.
Dinner—Carolina Inn, Chapel Hill, N. C.

8:30–10:00 P.M.

"The Uses of Mathematics in Watch Making"
(Mr. B. L. Hummel), Hamilton Watch Co., Head of Watch Design Dep't.
Discussion

August 13, Wednesday 11:30 A.M.–12:30 P.M.

"The Mathematics of Some Simple Mechanisms Used in Automatic Packaging Machines"
Mr. John W. May, Chief Engineer, Wright Automatic Machinery Co.
Discussion

2:00 P.M.

Visit to Western Electric Company, Burlington, N. C.

8:00–9:45 P.M.

"The Number System and One to One Correspondence"
Professor F. G. Dressel, Mathematics, Duke University
"Problem Sources and Problem Saving"
Professor J. W. Cell, Mathematics, N. C. State College
Discussion

August 14, Thursday 11:30 A.M.–12:30 P.M.

Panel Discussion—Students—Teachers—Textbooks
Miss Bonnie Cone, Charlotte, N. C.
Miss Veryl Schult, Washington, D. C.
Miss Frances Burns, Oneida, N. Y.

8:00–9:15 P.M.

"The Mathematics of Making and Fitting Lenses"
(Speaker to be announced), Optical Company

9:30 P.M.
Party—Rankin Home (Watermelons)

August 15, Friday 10:30 A.M.–12:00 Noon

"Curves Used In Engineering"
Professor W. J. Seeley, Head Electrical Engineering, Duke University
Study Group Reports
"Q.E.D."—Miss Veryl Shult

12:00 Noon—Adjournment

Registration Fee—$3.00
Room and board—$3.50 per day single room
$3.00 per day double room

STUDY GROUPS

I—8:30–9:30 A.M. Daily

Aids in the Study of Geometry (Junior and Senior High School)
Leader: Miss Frances Burns, Oneida High School, Oneida, N. Y.

II—8:30–9:30 A.M. Daily

Junior High School Mathematics
Leader: Miss Mary C. Rogers, Ch. Junior H. S. Research Com., Roosevelt Junior High School, Association of Mathematics Teachers of New Jersey, Westfield, N. J.

III—10:00–11:00 A.M. Daily

Making and Using Films, Instruments, Models
Leader: Mr. Roger W. Zinn, Educational Consultant, Jam Handy Organization, Detroit, Michigan

IV—10:00–11:00 A.M. Daily

The Enrichment of Mathematics (Junior and Senior H. S., College)
Leader: Miss Veryl Schult, Director of Mathematics, Washington City Schools

V—2:15–3:15 P.M. Daily

Tests and Measurements in Mathematics
Leader: Miss Elinor Douglas, Woodrow Wilson High School, Washington, D. C.

VI—3:30–4:30 P.M. Daily

Applications of Mathematics (High School and College Work)
Leader: Professor J. W. Cell, Mathematics, N. C. State College

VII—2:00–3:15 P.M. Daily

Field Work in Mathematics

Programs with detailed information will be available after May 1 and reservations may be made after that date.

W. W. RANKIN
Director of Mathematics Institute,
Duke University, Durham, N. C.

MATHEMATICS INSTITUTE, 1946

RUTH F. KIMBALL
Woodrow Wilson High School, Washington, D. C.

The Sixth annual Mathematics Institute which was held at Duke University August 8–17, 1946, was a most profitable experience, and one that brought both pleasure and satisfaction to those in attendance. Eighty students traveled eighty-four thousand miles to attend, coming from twenty-one states, Canada, and Puerto Rico. It is interesting to note that fifty-five per cent of the group held Masters degrees, and eight per cent Ph.D. degrees. The group included teachers at both high school and college levels.

The theme of the Institute was "Theory and Practice Getting Better Acquainted," and the program was planned to that end. Twice daily, at 10 A.M. and at 8 P.M. lectures were given by outstanding men in mathematics, science, and industry. The subjects presented by authorities in their respective fields included: "Atomic Energy," "Building Empirical Formulas Useful in Automotive Design," "Aids in the Study of Geometry," "The Mathematics of Radar," "Mathematics Used by the Chemical Engineer," and "Mathematics and the Scientific Method." In addition there were five study groups a day where members of the Institute discussed common problems, exchanged ideas, and contributed many valuable and concrete suggestions for the enrichment of the teaching program in mathematics. These study groups were: (1) Enrichment of Mathematics, (2) Consumer Mathematics, (3) Aids in the Study of Geometry, (4) Measurement and Computation, (5) Applications of Mathematics to Science and Engineering.

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